

PROGRAM AND ABSTRACTS FOR THE TWENTY- THIRD ANNUAL MEETING OF THE AMERICAN SOCIETY OF ZOÖLOGISTS

NEW HAVEN, CONNECTICUT, DECEMBER 28-30, 1925

These titles and abstracts make up the 1925 program of the American Society of Zoölogists. They were received either by the Secretary of the Society or by the Secretary of the joint Genetics Sections of the Society with the Botanical Society of America on or before November 20th, and have been arranged according to the accepted program rules.

The abstracts are in the form contributed by their authors. They have been edited only to secure a uniform system of titles and to reduce length when obviously overlong. Their arrangement and the planning of the program can be done only after the titles are all in hand and must be greatly rushed in order to obtain publication before the meetings. The Wistar Institute is scheduled to mail out this issue of *The Anatomical Record* three weeks, to the day, after receiving the manuscript. All proofreading will be done there. They deserve great credit for making possible the early publication and distribution of this material.

These abstracts and the accompanying historical data are presented as a part of the official proceedings of the 1925 meetings of the Society. The minutes of these meetings and a list of the officers and members of the Society as of January 1, 1926, will appear in the January number of this journal.

TENTATIVE PROGRAM

The tentative program shows the approximate half-day on which papers will be read. All sessions of the American Society of Zoölogists will be held in the Osborn Zoölogical Laboratory, corner of Prospect and Sachem Streets. The sessions of the American Society of Naturalists, at which the New Haven part of the program of the Genetics Sections will be given, will be held in the Sloane Physics Laboratory, second building north of the Osborn Zoölogical Laboratory on Prospect Street. The information concerning the program of the Genetics Sections has been furnished by their Secretary, Dr. D. F. Jones.

MONDAY, DECEMBER 28TH

- 10.00 A.M. Embryology, Cytology, Protozoology, Parasitology.
2.00 P.M. Comparative Anatomy, General Evolution, Ecology, Miscellaneous, General and Comparative Physiology.
4.30-6.00 P.M. Tea will be served to members of the Society by the ladies of the Department of Zoölogy at Yale University, Room 301, Osborn Zoölogical Laboratory.
7.00 P.M. Zoölogists' Dinner, President's Room, Memorial Hall, corner of College and Grove Streets.
The dinner address will be given by Ross G. Harrison, retiring President of the Society. All biologists are invited to attend.

TUESDAY, DECEMBER 29TH

- 9.00 A.M. General and Comparative Physiology (concluded).
Business Meeting.
2.30 P.M. Dedication of the New Building of the Peabody Museum, corner of Sachem Street and Whitney Avenue.
President Angell, of Yale University, will preside and several addresses will be given.
Following the dedication, there will be a reception and an opportunity to inspect the building.
8.30 P.M. Biological Smoker for the members of the American Society of Zoölogists and the American Society of Naturalists given by the local members of these Societies in cooperation with Yale University. Byers Hall, corner of College and Grove Streets.

WEDNESDAY, DECEMBER 30TH

9.00 A.M. Symposium: The cancer problem.

Genetic studies on the nature of cancer. L. C. Strong, Bussey Institute, Harvard University.

Discussion of certain etiological factors in the causation and transmission of malignant tumors. James B. Murphy, Rockefeller Institute.

The rôle of functional activity in the production of mammary carcinoma. Halsey J. Bagg, General Memorial Hospital and Cornell Medical College.

The medical, or tumor, aspects of the crowngall problem. Erwin F. Smith, Bureau of Plant Industry.

The discussion will be opened by James Ewing, Cornell University, and will be followed by a general discussion.

11.30 A.M. Inspection of exhibits.

4.30-6.00 P.M. Tea will be served to members of the Society by the ladies of the Department of Zoölogy at Yale University, Room 301, Osborn Zoölogical Laboratory.

LIST OF TITLES

EMBRYOLOGY

(To be read at New Haven.)

1. The reaction of the sand-dollar egg to the Cerebratulus sperm. Robert Chambers, Cornell University Medical College. Lantern. (10 min.)
2. The motility of the spermatozoon during the insemination of the sand-dollar egg. Robert Chambers, Cornell University Medical College. Lantern. (5 min.)
3. The specificity of sex, of organization, and of differentiation of embryonic chick gonads as shown by grafting experiments. B. H. Willier, University of Chicago. Lantern. (15 min.)
4. Amputation of the fore limb in rat embryos. J. S. Nicholas, University of Pittsburgh. Lantern. (15 min.)
5. Heteroplastic transplantations of the heart of Amblystoma embryos. W. M. Copenhaver, University of Rochester Medical School. Introduced by Ross G. Harrison. Lantern. (10 min.)
6. Heteroplastic transplantations of the eye in Amblystoma. Ross G. Harrison, Yale University. Lantern. (5 min.)
7. Proliferation, differentiation, and orientation of cells as distinct factors in the early development of the nervous system of Amblystoma. G. E. Coghill, The Wistar Institute and the University of Kansas. (15 min.)
8. Radiation effects on Arbacia germ cells. (Differential modification of development and reduction of fertilizing power of sperm.) Marie A. Hinrichs, University of Chicago. Opaque projection. (15 min.)
9. Further observations on parabiotic amphibian larvae. Robert K. Burns, Jr., University of Cincinnati. Introduced by H. L. Wieman. Lantern. (12 min.)
10. (Withdrawn.)

By title

- 11.¹ Germ-cell history of the male rat, from its origin to maturity. George T. Hargitt, Syracuse University.
- 12.¹ The production of size growth in Rana larvae by implants of the anterior lobe of the hypophysis. Bennet M. Allen, University of California, Southern branch.
- 13.¹ Color changes induced in Rana larvae by implantation of the intermediate lobe of the hypophysis. Bennet M. Allen, University of California, Southern Branch.
14. Testicular displacement and temperature regulation (rat, guinea-pig). Carl R. Moore, University of Chicago.

CYTOLOGY

(To be read at New Haven.)

15. The effect of Janus green on living eggs of Arbacia. Edmund B. Wilson, Columbia University. (15 min.)

¹ To be read before Section F of the American Association for the Advancement of Science meeting at Kansas City.

16. The chromosomes of the rabbit. Theophilus S. Painter, University of Texas. Lantern. (5 min.)
17. A comparative study of the chromosomes of the largest and the smallest races of rabbits. Theophilus S. Painter, University of Texas. Lantern. (5 min.)
18. A comparative study of mammalian chromosomes. Theophilus S. Painter, University of Texas. Lantern. (5 min.)

By title

- 19.¹ History of the germ cells in *Sphaerium striatinum*. Farris H. Woods, Junior College of Kansas City. Introduced by W. C. Curtis.
- 20.¹ The power of regeneration in three genera of planarians: *Planaria*, *Phagocata*, and *Dendrocoelum*. Marion F. Isely, University of Missouri. Introduced by W. C. Curtis.
- 21.¹ Storage of food in the eggs of *Fundulus*. Mary J. Guthrie, University of Missouri. Introduced by W. C. Curtis.
- 22.¹ Storage of food in the eggs of reptiles. Mary J. Guthrie and Donald F. Robertson, University of Missouri. Reported by Mr. Robertson. Introduced by W. C. Curtis.
- 23.¹ Number and behavior of the chromosomes in *Cavia cobaya* (the common guinea-pig). Mary T. Harman and Frank Root, Kansas State Agricultural College.
- 24.¹ The chromosomes of Doctor Nabours' parthenogenetically produced *Tettigidae*. W. R. B. Robertson, University of Missouri.
- 25.¹ The chromosomes in the cells of the embryonic membranes in the India runner duck. Mrs. Orilla Werner, University of Missouri. Introduced by W. R. B. Robertson.

PROTOZOOLOGY

(To be read at New Haven.)

- 26.² A study of *Lophomonas blattarum*, a flagellate inhabitant in the colon of *Blatta orientalis*. R. Kudo, University of Illinois. (5 min.)
- 27.² Division of *Endamoeba blattae*. R. Kudo, University of Illinois. (5 min.)
28. The relation of rhythms to nutrition and excretion in three species of *Paramecium*. W. Byers Unger, Dartmouth Collège. Introduced by L. L. Woodruff. Lantern. (8 min.)
- 29.² The interrelations of protozoa and the utricles of *Utricularia*. R. W. Hegner, Johns Hopkins University. (8 min.)
- 30.² Host-parasite relationships in Coccidiosis. Justin M. Andrews, Johns Hopkins University. Introduced by R. W. Hegner. (7 min.)
31. Morphology, fission, and conjugation of the *Balantidium* from the guinea-pig. Miriam J. Scott, University of Pennsylvania. Introduced by D. H. Wenrich. Lantern. (15 min.)
32. The intestinal protozoa of termites. Harold Kirby, Jr., Yale University. Introduced by L. L. Woodruff. Charts. (7 min.)

By title

- 33.¹ The effect of excisions on ameba. Lillian A. Philips, Cornell University. Introduced by A. A. Schaeffer.

²Author still uncertain on November 20th of the possibility of attending the meetings.

- 34.¹ Taxonomy and evolution of the amebas. A. A. Schaeffer, University of Kansas.
- 35.¹ Life-history of *Prorodon griseus*. G. W. Tannreuther, University of Missouri.
- 36.¹ Life-history of *Chilodon cucullulus* Ehrenberg. G. W. Tannreuther, University of Missouri.
- 37.¹ Growth of *Paramoecia* in pure cultures of *Pseudomonas pyocyaneus*. Charles H. Philpott, Harris Teachers' College. Introduced by W. C. Curtis.
38. Properties of the reproduction-inhibiting reaction product in infections with *Trypanosoma lewisi*. W. H. Taliaferro, University of Chicago.

PARASITOLOGY

(To be read at New Haven.)

- 39.² Microsporidia in the mosquitoes of Georgia. R. Kudo, University of Illinois. (5 min.)
40. A new semiparasitic copepod of the family Clausidiidae. Charles H. Blake, Massachusetts Institute of Technology. Introduced by R. P. Biglow. Charts. (10 min.)

By title

- 41.¹ Studies on the effect of parasitism upon the tissues. II. With special reference to a new diplostomous trematode found in the minnow, *Notropis anogenus* Forbes. H. P. Kjerschow Agersborg, James Millikin University.
42. Larval trematodes from Dry Tortugas. Harry M. Miller, Jr., Washington University. Introduced by Caswell Grave.
- 43.¹ Ectoparasitic infusoria attacking fish of Pacific Northwest. John E. Guberlet, University of Washington.
- 44.¹ The cestodes of the rhinoceroses. Horace W. Stunkard, New York University.
- 45.¹ A new blood fluke, *Unicaecum ruszkowskii*, n.g., n.sp.; A contribution to the relationship of the blood-infesting trematodes. Horace W. Stunkard, New York University.

COMPARATIVE ANATOMY

(To be read at New Haven.)

46. Anatomy of *Hendersonia*, a primitive helicinid mollusk. H. Burrington Baker, University of Pennsylvania. Lantern. (15 min.)
47. The occlusion of the digestive tract in reptiles. Albert M. Reese, West Virginia University. Lantern. (10 min.)
48. The pigment bodies of the hair-shafts of mammals, including man, and their relationships to species and to race. L. A. Hausman, Rutgers University. Introduced by T. C. Nelson. Lantern. (10 min.)
49. The smallest sucking fishes (Echeneididae) on record. E. W. Gudger, American Museum of Natural History. Opaque projection. (10 min.)
50. Autotomy in Arachnida. Florence Dowden Wood, Loyola University Medical School. Introduced by A. Petrunkevitch. Lantern. (10 min.)

By title

51. Possible scale vestiges in a urodele larva. Inez Whipple Wilder, Smith College.

52. The derivatives of the posterior cardinal vein in the rat. Martha Thompson Strong, Indiana University. Introduced by F. P. Reagan.
53. Certain features of vascular development as shown by injected rat embryos younger than mammalian embryos hitherto injected. Franklin P. Reagan, University of California.
54. The nervous mechanism of respiration in elasmobranch fishes. Mary Grace Springer, Barnard College, Columbia University. Introduced by F. H. Pike.
55. The cranium of the pleuracanthid sharks, with special reference to *Diacranodus*. L. Hussakof, American Museum of Natural History.
- 56.¹ Innervation of the head muscles of the albino mouse. W. A. Willard, University of Nebraska.

GENERAL EVOLUTION

(To be read at New Haven.)

57. The nature of the struggle for existence from the point of view of the second law of thermodynamics. F. H. Pike, Columbia University. (10 min.)

ECOLOGY

(To be read at New Haven.)

- 58.² A mussel survey of the upper Mississippi River. N. M. Grier, Dartmouth College, and R. H. Young, Northwestern University Medical School. Lantern. (15 min.)
- 59.² Environmental factors in relation to distribution of Panamanian fresh-water fishes. Ellinor H. Behre, Louisiana State University. (10 min.)

By title

60. Ecological studies on gasteropods. E. P. Cheatum, Southern Methodist University. Introduced by S. W. Geiser.
- 61.¹ A study of the nutrition of wood-boring mollusks. Robert C. Miller, University of Washington.

MISCELLANEOUS

(To be read at New Haven.)

62. Rate of growth and age at sexual maturity of certain sessile organisms. B. H. Grave, Wabash College. (10 min.)
63. The natural history of *Bugula* at Woods Hole, Massachusetts. B. H. Grave, Wabash College. (5 min.)
- 64.² Further studies on the life-history of *Craspedacusta ryderi*, a fresh-water medusa. Fernandus Payne, Indiana University. (10 min.)
- 65.² The earlier larval instars of the Odonata. Philip P. Calvert, University of Pennsylvania. Lantern. (15 min.)
66. Variation in the number of fin-rays in three species of *Fundulus*. R. P. Biglow. Charts. (5 min.)
67. A simplified method for the cultivation of living tissues in vitro. George A. Baitsell, Yale University. (15 min.)

By title

- 68.¹ A cruise on a New Zealand trawler. C. C. Nutting, University of Iowa.
 69. A collection of fresh-water fishes from western Panama. Ellinor H. Behre, Louisiana State University.
 70. A rapid iron-hematoxylin method. Elbert C. Cole, Williams College.

GENERAL AND COMPARATIVE PHYSIOLOGY

(To be read at New Haven.)

71. Blood calcium (parathyroid) changes and the reproductive cycle in pigeons: A contribution to the sex problem. Oscar Riddle and Warren H. Reinhart, Station for Experimental Evolution. Lantern. (15 min.)
 72. The spawning of *Teredo navalis*, L. T. C. Nelson, Rutgers University. Lantern. (5 min.)
 73. On the antagonism between thyroid and ovary in relation to the formation of plumage melanins in the domestic fowl. Harry Beal Torrey and Benjamin Horning, University of Oregon. Lantern. (15 min.)
 74. Factors causing or associated with cold hardiness in insects. Nellie M. Payne, University of Pennsylvania. Introduced by J. H. Bodine. (15 min.)
 75.² Chemical reactions of *Nereis virens*. Manton Copeland, Bowdoin College. (15 min.)
 76. The prevention and cure of tetany by oral administration of strontium. W. W. Swingle and Wm. Wenner, Yale University. Lantern. (8 min.)
 77. The effect of bleeding upon the serum calcium of parathyroidectomized dogs. W. W. Swingle and Wm. Wenner, Yale University, and the Biological Laboratory, Cold Spring Harbor. Lantern. (7 min.)
 78. The locomotion of the sand-dollar *Echinarachnius*. G. H. Parker, Harvard University. (15 min.)
 79. Metabolic rate and bunching in catfish. M. W. Eddy, Dickinson College. Introduced by W. C. Allee. (15 min.)
 80. Observations of the food reactions of *Actinophrys sol*. J. B. Looper, University of Virginia. Introduced by Wm. A. Kepner. (10 min.)
 81. Reactions of *Hydra* to inanition. Wm. A. Kepner and P. N. Jester, University of Virginia. (5 min.)
 82. Specificity of integument in the spotted newt, *Triturus viridescens*. H. H. Collins, University of Pittsburgh, and E. F. Adolph, University of Rochester. Lantern. (10 min.)

By title

- 83.¹ Autotomy and regeneration in the house centipede, *Scutigera* forceps. John A. Cameron, University of Nebraska. Introduced by D. D. Whitney.
 84.¹ The effect of breathing cigarette smoke upon young rabbits. W. J. Baumgartner, University of Kansas.
 85. The nerve plexus of the earthworm, *Lumbricus terrestris*. Walter N. Hess, Depauw University.
 86. The effect of bunching on oxygen consumption in land isopods. W. C. Allee, The University of Chicago.

- 87.¹ The disintegration of *Planaria maculata* in KCN. J. W. Wilson, Brown University.
- 88.¹ Some conditions affecting the hibernation of the thirteen-lined ground-squirrel, *Citellus tridecemlineatus*. George Edwin Johnson, Kansas State Agricultural College.
89. The effect of ultraviolet radiation upon the tetany syndrome. W. W. Swingle and J. G. Rhinhold, Yale University.
90. The relation of the mammalian follicular hormone to the development of secondary sexual characters. W. W. Swingle, Wm. Wenner, and M. Steggerda, Biological Laboratory, Cold Spring Harbor, and Yale University.
91. The effect of thyroidectomy and glucose administration on the life-span of adrenalectomized cats. R. L. Zwemer, Yale University. Introduced by W. W. Swingle.
- 92.¹ The ovarian follicular hormone: variations in amount in pig, cow, and human ovaries during the oestrous and menstrual cycles. Edgar Allen, University of Missouri School of Medicine.
- 93.¹ Some observations on the spiral movements in mice. Inez Dunkelberger, University of Kansas. Introduced by A. A. Schaeffer.
94. Nutrition of the ovum of *Hydra*. Wm. A. Kepner and J. B. Looper, University of Virginia.
95. Further experiments upon the regulation of body volume in earthworms. Edward F. Adolph, University of Rochester.

GENETICS

(To be read at New Haven.)

96. The fertility behavior of the black rat, *Mus rattus*, a wild species under domestication. H. W. Feldman, Bussey Institution. Introduced by W. E. Castle. Lantern. (15 min.)
97. On a mendelizing structural defect of the retina producing blindness in the house mouse. C. E. Keeler, Bussey Institution. Introduced by W. E. Castle. Lantern. (10 min.)
98. A case of non-disjunction of an autosome in mammals. W. H. Gates, Louisiana State University. By introduction. (15 min.)
99. Further experiments with x-rayed mice and their descendants. H. J. Bagg, E. C. MacDowell, and E. M. Lord, Cornell Medical School and Carnegie Institution. (15 min.)
100. Factors influencing the number of corpora lutea in mice; parity vs. age. E. C. MacDowell and E. M. Lord, Carnegie Institution. Lantern. (10 min.)
101. Egg production of a cross between two highly productive races. H. D. Goodale, Mount Hope Farm, Williamstown, Massachusetts. (10 min.)
102. Data on the inheritance of spurs in the female of domestic poultry. H. D. Goodale, Mount Hope Farm, Williamstown, Massachusetts. (10 min.)
103. The genetic relations of some shank colors of the domestic fowl. L. C. Dunn, Storrs Agricultural Experiment Station. (15 min.)
104. Observations on the cellular basis and embryonic development of mendelian characters in the Japanese fish, *Aplocheilus latipes*. H. B. Goodrich, Wesleyan University. Lantern. Chart. (12 min.)

105. Temperature as a factor in sex control in Cladocera. A. M. Banta and L. A. Brown, Carnegie Institution. Lantern. (15 min.)
106. Races or subspecies in Reticulitermes. T. E. Snyder, U. S. Department of Agriculture. Charts. (15 min.)
107. Reddish—a frequently 'mutating' character in *Drosophila virilis*. M. Demeree, Carnegie Institution. Lantern. (10 min.)
108. Mutations in *Drosophila virilis* and their bearing on the homology of genes. Alexander Weinstein, Johns Hopkins University. (15 min.)
109. An interracial cross in *Drosophila obscura* producing partially fertile hybrids. D. E. Lancefield, Columbia University. (10 min.)
110. Chromosome behavior in *Sciara* (Diptera). C. W. Metz, Carnegie Institution. Lantern. (15 min.)
111. The non-functioning of the genes in spermatozoa. H. J. Muller and F. Settles, University of Texas. Charts. (15 min.)
112. Human blood groups, their inheritance and racial significance. L. H. Snyder, North Carolina State College. Introduced by W. E. Castle. (10 min.)
113. Dementia praecox in identical twins. G. H. Parker, Harvard University. (10 min.)
114. Genetics and morphology of some endosperm characters in maize. P. C. Mangelsdorf, Connecticut Agricultural Experiment Station. Lantern. (15 min.)
115. A genetic interpretation of ecological adaptation. Karl Sax, Maine Agricultural Experiment Station. (10 min.)
116. Heteroploidy and somatic variation in Dutch flower bulbs. W. E. de Mol, Columbia University.
117. The instability of so-called bacterial species, with special reference to microbial dissociation and the action of the bacteriophage of d'Herelle. Philip Hadley, University of Michigan.
118. Sex in a fraternity of pigeons obtained from an interfamily cross. Oscar Riddle, Station for Experimental Evolution.

By title

119. Genetic linkage in the tomato. John W. McArthur, University of Toronto and Ontario Agricultural College.
120. A spontaneous chimera in the tomato. John W. McArthur, University of Toronto and Ontario Agricultural College.
- 121.¹ A geographical study of variation in two species of iris. Edgar Anderson, Missouri Botanical Garden. Introduced by G. T. Moore. (15 min.)
- 122.¹ The expression of mendelian factors in the gametophyte of maize. D. F. Jones and P. C. Mangelsdorf, Connecticut Agricultural Experiment Station. (10 min.)
- 123.¹ A study of pollen tube growth in relation to sterility between two species: *Datura stramonium* and *Datura meteloides*. J. T. Buchholz and A. F. Blakeslee, University of Arkansas and Carnegie Institution. Lantern. (12 min.)
- 124.¹ Genetic linkages between size and color factors in the tomato. E. W. Lindstrom, Iowa State College. Charts. (12 min.)

- 125.¹ Sex expression in spinach. J. T. Rosa, California College of Agriculture. (5 min.)
- 126.¹ Sex in plants compared with sex in animals. H. W. Rickett, University of Missouri. (15 min.)
- 127.¹ The effect of selection on spore size in pure lines of *Helminthosporium*. C. D. La Rue, University of Michigan. Lantern. (10 min.)
- 128.¹ One hundred 'mutants' in the genus *Fusarium*. L. H. Leonian, West Virginia Agricultural Experiment Station. Lantern. (15 min.)
- 129.¹ The frequency of mutation in maize. L. J. Stadler, Bussey Institution. (8 min.)
- 130.¹ Primary and double chromosomal types in the offspring of triploid daturas. A. F. Blakeslee and Gordon Morrison, Carnegie Institution. (10 min.)
- 131.¹ Inheritance of plumage color in the Rhode Island Red breed of domestic fowl. F. A. Hays, Massachusetts College of Agriculture. (10 min.)
- 132.¹ Five new color factors in Guinea-pigs. H. L. Ibsen, Kansas Agricultural College. Lantern. (15 min.)
- 133.¹ Effect of ovarian injury on egg-laying in fowls. Morris Steggerda, University of Illinois. Introduced by Charles Zeleny. Lantern. (15 min.)
- 134.¹ Evidence of somatic segregation of factors for plumage color in heterozygotes in the turkey. W. R. B. Robertson, University of Missouri. Lantern. Charts. Exhibit. (15 min.)
- 135.¹ Non-inheritance of the temperature effect on bar eye in *Drosophila melanogaster*. Charles Zeleny, University of Illinois. Lantern. (15 min.)
- 136.¹ Effects of ten generations of alcoholism upon albino rats. F. B. Hanson, Washington University. Lantern. (10 min.)
- 137.¹ Alcohol and the sex ratio. Florence Heys, Washington University. Introduced by F. B. Hanson. Lantern. (5 min.)
- 138.¹ Studies on inheritance in *Stagmomantis carolina*. E. H. Ingersoll, Kansas Agricultural Experiment Station. Introduced by R. K. Nabours. Lantern. (10 min.)
- 139.¹ Parthenogenesis in the grouse locust, *Paratettix texanus*, Hancock. R. K. Nabours and Martha E. Foster, Kansas Agricultural College. (10 min.)
- 140.¹ The inheritance of horns, wattles, and color in goats. J. L. Lush, Texas Agricultural Experiment Station. Introduced by L. J. Cole. (15 min.)

EXHIBITS

1. Amputation of the fore limb in rat embryos. J. S. Nicholas, Medical School. University of Pittsburgh.
2. Heteroplastic grafts in *Amblystoma*. Ross G. Harrison, Yale University.
3. Parabiotic amphibian larvae. Robert K. Burns, Jr., University of Cincinnati.
4. Mosquito larvae suffering from microsporidian infection. R. Kudo, University of Illinois.
5. *Hersiliopsis welshi*, a new semiparasitic copepod from *Arenicola cristata*. Charles H. Blake, Massachusetts Institute of Technology.
6. Cultures of adult frog tissues in vitro. George A. Baitsell, Yale University.
7. Tortugas sponges grown from dissociated cells, and photographs of the same. H. V. Wilson, University of North Carolina.

- 8.³ Drawings of color pattern variations in *Stagmomantis carolina*. E. H. Ingersoll, Kansas Agricultural Experiment Station.
- 9.³ Skins illustrating the interrelations of the chief color factors involved in crosses between eight breeds of the domestic turkey. W. R. B. Robertson, University of Missouri.
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³ Genetics exhibits at Kansas City.

ABSTRACTS

EMBRYOLOGY

(To be read at New Haven.)

1. *The reaction of the sand-dollar egg to the Cerebratulus sperm.* ROBERT CHAMBERS, Cornell University Medical College. (Lantern; 10 min.)

The spermatozoon of the *Cerebratulus lacteus* has a twisted, sickle-shaped, tapering head and, while in motion, advances in a series of corkscrew turns. It can actively burrow its way into the sand-dollar egg. This is performed exclusively by the lashing of its tail. After the head has partially penetrated, the tail ceases movement, as if from fatigue. The head then begins to slip back. This occurs apparently because of the resistance offered by the elasticity of the egg substance to the tapering, wedge-shaped head. After a few seconds the tail resumes its lashing movement and again drives the head in. This performance of alternating activity and quiescence terminates either in a successful entrance of the sperm or in its complete discard. Even after the successful entry of the sperm, the egg is still able to continue hostilities. In such a case small vacuoles appear around the spermatozoon. These coalesce into a large vacuole within which the spermatozoon lies inert and in every case fails to effect a successful union with the female pronucleus.

2. *The motility of the spermatozoon during the insemination of the sand-dollar egg.* ROBERT CHAMBERS, Cornell University Medical College. (Lantern; 5 min.)

In a previous communication I described the passive nature of the spermatozoon in the insemination of the starfish egg.

In the sand-dollar the insemination is due largely to the active penetration of the spermatozoon. If the tip of its head becomes adherent to the egg, the spermatozoon burrows its way in by a continual rotation of the head on its tip as a fixed pivot, while the tail performs a lashing movement. If the sperm is exceedingly active, the entire tail is carried into the interior of the egg, where the lashing movement continues for some time. This is strikingly noticeable because of the agitation imparted to the cytoplasmic granules. Usually, however, the movement of the tail ceases after the head has penetrated the egg.

If the fertilization membrane lifts rapidly, it permits the tail to pass through until the entire tail lies within the membrane. If the membrane rises slowly, the tail is caught by the membrane. As this continues to rise, it puts a tension on the tail which breaks at any place along its stretched length.

Although the penetration of the spermatozoon depends largely on the activity of the spermatozoon, the egg must be in a receptive state to allow the adhesion of the tip of the spermatozoon to the egg's surface.

3. *The specificity of sex, of organization, and of differentiation of embryonic chick gonads as shown by grafting experiments.* B. H. WILLIER, University of Chicago. (Lantern; 15 min.)

Embryonic chick gonads, in either the morphologically 'indifferent' or the sexually differentiated stages of development, were transplanted to the vascular chorio-allantoic membranes of host chick embryos. The gonads were implanted to host embryos on the ninth day of incubation and permitted to grow for nine days, when they were examined histologically.

1. The indifferent gonads were from donor embryos incubated four, five, and six plus days. The right indifferent gonad differentiates into either a testis or a right ovary, while the left indifferent gonad differentiates into either a testis or a left ovary. Thus the indifferent gonad from the time of its origin is specifically organized with respect to sex and, in the case of the female, with respect to laterality. This specific organization is detectable as early as the fourth day of incubation, the approximate time of the origin of the genital ridge.

These results furthermore show that the right and left gonads have the capacity for independent growth and differentiation, for they differentiate according to their specific organizations and are not modified by the sex of the host embryo. Apparently hormonal sex differentiating factors are either absent or, if present, they are ineffective in the modification of the engrafted sexual glands.

2. The sexually differentiated gonads (from embryos incubated seven, nine, ten, eleven, twelve, and thirteen days) when implanted to male and female host embryos continue to develop in essentially a normal manner regardless of the sex of the host embryos.

4. *Amputation of the fore limb in rat embryos.* J. S. NICHOLAS, University of Pittsburgh. (Lantern; 15 min.)

Experiments have been devised to test the powers of regeneration of rat embryos in utero. Those here reported deal with the powers of healing after the amputation of the fore limb.

The experiments fall naturally into two groups: those in which the stage of development, grading from the fourteenth day of gestation to the day before birth, was the variable factor and those in which the amount of tissue amputated was varied. In all cases there is healing, but no regeneration of the missing structures.

The animals which have been so treated during their embryonic existence generally survive to the end of the gestation period and are born with the rest of the litter. Postnatal observation of the experimental animals is generally limited, as those operated upon tend to succumb. In one case, however, the postnatal development of an operated animal has been followed for several weeks. There is no postnatal regeneration of parts which have been amputated during intra-uterine development.

The results here reported cannot be said to prove conclusively that there is no regeneration during mammalian development, but they certainly show that, during the latter third of the gestation period, regenerative potency is limited to the normal processes of wound healing. It is believed that these are the first controlled experiments giving positive evidence on this question.

5. *Heteroplastic transplantations of the heart of Amblystoma embryos.* W. M. COPENHAVER, University of Rochester Medical School. (Introduced by Ross G. Harrison.) (Lantern; 10 min.)

Experiments were made at the Osborn Zoölogical Laboratory, Yale University, in 1924 and 1925 to determine the effect of heteroplastic transplantation of the heart, as previously done by Harrison for the limb, where a marked effect of host upon the rate of growth of the graft was shown to occur.

During the early stages of normal development the heart is of approximately the same size in embryos of *Amblystoma punctatum* and *Amblystoma tigrinum* of corresponding age and stage of differentiation. In later stages, as the time for metamorphosis approaches in punctatum, tigrinum embryos grow more rapidly and consequently have larger hearts than punctatum embryos. Throughout embryonal life the rate of beat is distinctly higher in punctatum than in tigrinum.

After transplantation of the heart rudiment from tigrinum to punctatum embryos, the growth of the heart is greatly accelerated. By the time the yolk is completely resorbed the grafted heart is already somewhat larger than that of either normal control, and by the end of sixty days the organ is at least twice the size of the heart of control punctatum embryos.

After transplantations from punctatum to tigrinum embryos, growth is retarded; the heart is smaller than in either punctatum or tigrinum controls. These embryos lived for only a few weeks.

In all operated embryos the pulsation rate was that of the donor species; for example, a punctatum embryo with a tigrinum heart innervated by a punctatum vagus maintained the tigrinum rate.

6. *Heteroplastic transplantations of the eye in Amblystoma.* ROSS G. HARRISON, Yale University. (Lantern; 5 min.)

Like the limb, the eye in heteroplastic transplantations between *Amblystoma punctatum* and *tigrinum* shows an effect of host on graft in respect to rate of growth. The optic vesicle, with normal covering of cornea- and lens-forming ectoderm, heals readily on embryos of the other species and undergoes normal development except in size. The tigrinum eye in the punctatum embryo is greatly accelerated in growth, and before metamorphosis may attain linear dimensions double those of normal punctatum eyes and considerably larger than those of the normal eye of the donor species. The eye of the punctatum embryo transplanted to tigrinum is retarded in growth below the normal of either species. When the eye vesicle of *A. tigrinum* is transplanted without cornea and lens ectoderm, its growth is accelerated, but to lesser degree. The reciprocal experiment did not succeed. When corneal-lens epithelium alone is transplanted, the lens formed is similarly affected, being at first either too large or too small. The lens of abnormal size reacts, however, upon the optic vesicle; for in the tigrinum-punctatum grafts the eye vesicle increases in size above that of the normal of either species. Here again the magnitude of the effect is less than when the whole eyes are transplanted. Grafts between embryos of *A. punctatum* and those of the axolotl, which is considered by some to be a variety of *A. tigrinum*, show similar effect, but less in degree.

7. *Proliferation, differentiation, and orientation of cells as distinct factors in the early development of the nervous system of Amblystoma.* G. E. COGHILL, The Wistar Institute and the University of Kansas. (15 min.)

Proliferation and differentiation in the nervous system of *Amblystoma* cannot be activated by the same agency, since they operate chiefly (not exclusively) in different localities, their pulses of acceleration are not synchronous, and they differ in metabolism. Differentiation in the basal plate progresses according to a pattern that conforms in the main to neuromerism and, in the larger features, is correlated with the earliest known structural differentiation in the medullary plate. It is, therefore, probably the expression of relative rates of metabolism that are initiated as early as the medullary-plate stage. Since this antedates the segmentation of the mesoderm, differentiation cannot be activated by the latter. The activating agencies of differentiation in the nervous system must, therefore, be intrinsic at a very early stage. The orientation of early neuroblasts takes place in definite relation to the external limiting membrane in such a manner as to establish a strong presumption that this membrane is an essential factor in the process. Since the earliest orientation of cells is longitudinal and is initiated at about the time the embryo begins to elongate, and since there are known to be longitudinal physiological gradients operating in the organism at this time, it is reasonable to believe that these gradients, or their concomitants of some order, acting upon or through the external limiting membrane, activate the early orientation of neuroblasts. In efforts to analyze the dynamics of the development of the nervous system, distinction should be made between these three processes.

8. *Radiation effects on Arbacia germ cells. (Differential modifications of development and reduction of fertilizing power of sperm.)* MARIE A. HINRICHS, University of Chicago. (Opaque projection; 15 min.)

When one or the other germ cell of *Arbacia* is exposed to radiation before fertilization, development is modified in the same way as when fertilized eggs are exposed. With stronger doses of radiation, a permanent inhibition follows as the result of a retardation or suppression in the development of the median anterior regions of the body. With a lesser dosage, however, these regions may acclimate to, or recover from, the injurious effects of radiation; i.e., they may regain or even surpass their normal relative developmental rates. A secondary recovery or acclimation may, under certain conditions, follow a primary inhibition, and in such cases the apical regions are overdeveloped and the basal regions underdeveloped, showing that the most active regions recover most rapidly.

In the fertilization of normal eggs, injured sperm may be considered as having toxic properties, hence it exerts an inhibiting influence on the egg protoplasm and interferes with normal development. Since the developing embryos are differentially modified, it is evident that there must have been early differences in the capacity of various regions of the cytoplasm of the unfertilized egg to adjust themselves to the incorporation of incompatible sperm protoplasm to form the zygote.

Ultraviolet radiation markedly reduces the fertilizing power of sperm. The degree of reduction is in general proportional to the dilution of the sperm suspension, and the rate of reduction due to the time factor is greater in radiated

than in non-radiated suspensions. The loss by diffusion of a substance necessary for fertilization is probably responsible for the falling off of fertilizing power; sperm motility is also greatly reduced.

9. *Further observations on parabiotic amphibian larvae.* ROBERT K. BURNS, JR., University of Cincinnati. (Introduced by H. L. Wieman.) (Lantern; 12 min.)

Amblystoma punctatum embryos grafted side to side just after closure of the neural tube may grow parabiotically to metamorphosis or beyond. Pairs are invariably of the same sex, although, according to the law of probability, one-half of all pairs should be of different sex. Eighty such pairs showed forty-four ♂♂ and thirty-six ♀♀ (Burns, '25). Although the mortality was great enough to account for the absence of ♂♀ pairs, there were good reasons for believing that transformation of sex had occurred.

In an effort to eliminate the mortality factor, new series of experiments were undertaken.

1. Amblystoma tigrinum, a larger and more vigorous species, was used as one member of the pair. Mortality was kept below 18 per cent.

2. A smaller number of pairs were given painstaking care throughout larval life. The results confirm the previous experiment and are here summarized:

1a. Forty-four pairs of animals yielded twenty-three ♂♂, twenty-one ♀♀, and no ♂♀.

b. A. tigrinum, although much smaller at operation, soon overtook and then greatly exceeded in size the A. punctatum member.

c. Compared with normal controls, both members of pairs were subnormal in size, but A. punctatum suffered much the greater retardation.

d. Sex differentiation began earlier in A. tigrinum and was at all times further advanced.

e. Larval life of A. punctatum was greatly prolonged.

An examination of the glands of internal secretion in the pairs will be undertaken.

2. Sixteen pairs of animals examined in this series showed nine ♂♂ and seven ♀♀. Mortality less than 15 per cent.

10. (Withdrawn.)

By title

- 11.¹ *Germ-cell history of the male rat, from its origin to maturity.* GEORGE T. HARGITT, Syracuse University.

The testis is differentiated from the indifferent gonad in embryos of fourteen days. The indifferent gonad and the sex cords contain large and small cells, both of which are derived from the coelomic epithelium. The large cells have generally been called primordial germ cells, they increase by mitosis and reach their maximum in embryos of seventeen days. But all the large cells degenerate and have completely disappeared by nine days after birth. The large cells, therefore,

¹To be read before Section F of the American Association for the Advancement of Science meeting at Kansas City.

do not contribute to the formation of cells in the tubules of the adult testis. After the disappearance of the large cells, the solid seminiferous tubules are composed of indifferent epithelial cells of a uniform type which are descendants of the small cells of the genital ridge, and which later form both the germ cells and the Sertoli cells of the seminiferous tubules of the adult testis.

Definitive spermatogonia begin to form fifteen days after birth when the solid cords are becoming hollow tubules, spermatocytes occur at twenty-three days when the testes are entering the inguinal canals, spermatids are first observed about thirty-three days when the testes enter the scrotum, and perfect spermatozoa at forty-eight days. Sertoli cells cannot be distinguished until almost puberty; these cells may be only indifferent epithelial cells. During the development of the seminiferous tubules a good many cells of all stages of spermatogenesis degenerate.

12.¹ *The production of size growth in Rana larvae by implants of the anterior lobe of the hypophysis.* BENNET M. ALLEN, University of California, Southern Branch.

The rate of growth in normal controls and thyroidless controls is about equal, while pituitaryless controls show a distinctly lower curve of growth. Anterior, intermediate, and posterior lobes of the hypophysis dissected out of adult frogs are implanted subcutaneously into tadpoles from which the hypophysis (except posterior lobe) has been removed. Measurements of the total length of the operated tadpoles are made every seven days. A normal rate of size growth is restored by implantation of the anterior lobe. The curve of growth thus induced shows an initial sharp rise until normal size is restored, after which it coincides with normal growth rate and finally declines, owing to metamorphosis which it induces in cooperation with the thyroid gland.

Neither implantation of the intermediate lobe nor of the posterior lobe has any influence upon size growth, the anterior lobe being alone concerned. This is well shown by first implanting an intermediate or posterior lobe of the hypophysis into a pituitaryless tadpole and then after several weeks implanting an anterior lobe. The former causes no acceleration of growth, while the implantation of the anterior lobe causes a sharp rise in the growth curve.

That this acceleration of growth is caused by the activity of the living gland and not by stored secretions is shown by the fact that transplantation of dead anterior hypophysis does not stimulate growth, although the dead substance is resorbed.

13.¹ *Color changes induced in Rana larvae by implantation of the intermediate lobe of the hypophysis.* BENNET M. ALLEN, University of California, Southern Branch.

In 1920 implantation of the fused intermediate and posterior lobes of the hypophysis of adult *Rana pipiens* restored pituitaryless tadpoles of that species to their normal color and made them even darker.

In recent experiments upon *Rana aurora draytoni*, portions of the intermediate lobe sliced off of the hypophysis of the adult frog and implanted subcutaneously into tadpoles cause them to assume an intense black color very much darker

than the gray of normal tadpoles, due to the fact that the adult tissues have a bulk many times greater than that normal to tadpoles. The color change is gradual, requiring about ten days.

Histological study shows a great increase in the number and expansion of the superficial melanophores, expansion of the deep melanophores, contraction of the xantholeucophores, and a very striking deposition of black pigment in lens-shaped masses upon the peripheral side of the nucleus of each cell of the deep layer of the epidermis.

This color restoration is not produced by implantation of either the anterior or posterior lobe and appears to be due solely to the action of the intermediate lobe, although the pars tuberalis has not been taken into account because of technical difficulties. That these phenomena are caused by the living gland and not by absorption of stored secretions was demonstrated by absence of color influences in cases where the dead gland was implanted.

14. Testicular displacement and temperature regulation (rat, guinea-pig). CARL R. MOORE, University of Chicago.

When the two testes of a prepubertal rat or guinea-pig are removed from the scrotum, one being transferred to a subcutaneous position, the other to the abdomen, spermatogenesis continues in the former for months (three to nine months), but not in the latter. In each case the vas deferens, nerve, and blood supply are intact.

The subcutaneous testis tubules contain spermatogonia, spermatocytes, and spermatids, with quantities of mitotic figures, but spermatozoa have not been seen. Such a condition is to be contrasted with the abdominal testis where usually only Sertoli cells are to be found in the seminiferous tubules.

Despite the greater severity of operative manipulation, the subcutaneous testis all but accomplishes spermatozoon differentiation, whereas the abdominal testis has been deprived of practically all elements of the germinal line. In the light of earlier work, this is interpreted to mean that a subcutaneous environment more nearly approaches that of the scrotum than does the abdomen. The scrotal regulatory effect, impossible among the viscera, is partially realized through ordinary skin. This skin regulation of heat loss apparently cannot entirely substitute for scrotal regulation, but its effectiveness, though slightly under the minimum threshold, is indicated by the nearness to spermatozoon formation.

CYTOLOGY

(To be read at New Haven.)

15. The effect of Janus green on living eggs of Arbacia. EDMUND B. WILSON, Columbia University. (15 min.)

Living eggs of the sea-urchin *Arbacia punctulata* treated with dilute solutions of Janus green B (shown by previous tests to stain typically the chondriosomes of other kinds of cells) consistently show the following effect, apparently of undescribed type.

1. The dye acts solely on the chromatophores (pigment granules), which are finally stained intensely blue-black, as follows:

2. A single, minute, brilliantly stained, centriole-like area appears exactly at the periphery of each chromatophore and gradually enlarges to form a sharply bounded sphere extending inward. The unstained region is thus reduced to a crescent, and finally is totally eclipsed, the whole chromatophore now being intensely and uniformly stained. Fertilized eggs thus treated may undergo the first cleavage, the chromatophores migrating to the periphery as in normal eggs.

3. Invariably the staining process begins at a single, sharply localized point in respect to the location of which no correlation exists between different chromatophores or with the egg axis.

4. The size of the stained area at each stage is proportional to the size of the chromatophore. Its growth continues only so long as the unstained area remains intact. With breakdown of the latter the action ceases.

5. Fixed eggs, after the approved chondriosome-technique (Benda, Altmann-Meves, Champy-Kull), show the chromatophores unstained, the chondriosomes as numerous, minute, intensely stained granules scattered among the megasomes, substantially as figured by Meves in *Parechinus*. They are but slightly displaced by centrifuging, while the chromatophores mass toward the heavy pole.

16. *The chromosomes of the rabbit.* THEOPHILUS S. PAINTER, University of Texas. (Lantern; 5 min.)

This study was made to determine the diploid chromosome number of the rabbit, the method of sex determination, and to test out the value of somatic divisions for the study of chromosome morphology and diploid counts. Counts on amniotic cells of twelve young embryos gave constantly a diploid number of forty-four chromosomes. When these chromosomes were mated up according to size and shape, in part of the cases all elements had mates of like size and shape (female embryos), while other embryos showed two chromosomes, one medium sized, the other small with no mates of like size or shape (male embryos).

A study of the spermatogenesis confirms the somatic count of forty-four as the true diploid number, and X-Y sex chromosomes have been identified in first maturation division.

It was found that there was a tendency for the chromosomes in the amnia of old embryos to show some fragmentation, and hence such tissue would not be a reliable index for the true diploid number. Young amniotic tissue has been found excellent for determining the diploid number and the morphology of the individual chromosomes.

17. *A comparative study of the chromosomes of the largest and the smallest races of rabbits.* THEOPHILUS S. PAINTER, University of Texas. (Lantern; 5 min.)

The object of this work was to determine if there is any appreciable difference in the chromosomes of races of rabbits as different in size as the Flemish Giant and the Polish. Crosses were made between individuals of these two races and the amniotic cells of the resulting embryos studied. It was found that the chromosomes of these two races were alike in number and in size and shape.

18. *A comparative study of mammalian chromosomes.* THEOPHILUS S. PAINTER, University of Texas. (Lantern; 5 min.)

In this paper the writer will summarize the results of his mammalian chromosome studies which include species from seven different orders. The most striking fact, perhaps, is the general similarity of the chromosomes of the eutheria. The number is always high, ranging from forty-two to sixty chromosomes, and the evidence at hand indicates that the primitive number was originally about forty-eight, and that deviations from this are due either to end-to-end fusion or to fragmentation. The theoretical bearing of these facts will be discussed.

By title

- 19.¹ *History of the germ cells in Sphaerium striatinum.* FARRIS H. WOODS, Junior College of Kansas City. (Introduced by W. C. Curtis.)

Certain phases of the germ-cell cycle in *Sphaerium* have been described, but the exact origin of the germ cells and their complete history have not been described previously for this species.

Observations upon living and sectioned material covering the various stages in the life-cycle show that the germ-cell history is traceable from fertilized egg to sexual maturity. The cycle may be divided into six general periods with definite limits.

Primordial germ cells of characteristic structure appear just before gastrulation. One large germ cell appears in the mesoderm mass on either side of the blastocoel. Cell lineage before gastrulation shows the paired germinal elements to arise from the third cleavage of the fourth generation of micromeres arising from the cell D of the four-cell stage.

All germ cells are direct descendants of the two primordial germ cells visible just before gastrulation. The ectomesoblasts contribute nothing to the formation of the germ cells. Metamorphosis of somatic cells into germ cells has not been observed in the material studied, nor change of germ cells into somatic cells. There is no precocious maturation of either spermatogonia or oogonia.

During maturation certain granules appear in the cytoplasm of the ovum. During cleavage these granules segregate into those cells which give rise to the germ cells, indicating that they may prove to be germ-cell determinants. The investigation is being continued upon the origin, nature, and significance of these granules and upon the development of the hermaphrodite gland.

- 20.¹ *The power of regeneration in three genera of planarians: Planaria, Phagocata, and Dendrocoelum.* MARION F. ISELY, University of Missouri. (Introduced by W. C. Curtis.)

Further investigations upon the formative cells of planarians in relation to regeneration, as reported last year by Curtis and Schulze, give more exact determinations of the power of regeneration in the three species, *Planaria maculata*, *Phagocata gracilis*, and *Dendrocoelum lacteum*. When individuals of these three species were cut transversely into three pieces of about equal size and the corresponding pieces kept together in watch-glasses, *P. maculata* pieces all regenerated completely in nine days, including equal distribution of pigment; *Phagocata* showed definite but incomplete areas of regenerating tissue; in

Dendrocoelum all the mid-pieces died, the tail-pieces healed, and the head-pieces showed regenerating tissue. In other experiments Phagocata regenerated completely, but at so slow a rate that the worms lacked normal pigmentation even after sixty days; while in Dendrocoelum pieces cut anterior to the pharynx regenerated both a head and a tail, and those cut posterior to the pharynx regenerated a tail but no head. It is a familiar fact that *P. maculata* can regenerate effectively when cut transversely into more than three pieces.

P. maculata has, therefore, a high capacity and a high rate of regeneration; Phagocata the capacity, but a lower rate, and Dendrocoelum a very limited capacity and a very slow rate even in such regions as are capable of regeneration. These facts are correlated with the abundance of formative cells. The significance of the formative cells is further indicated by other observations and experiments upon *P. velata*, *P. formanii*, and *P. agilis*.

21.² *Storage of food in the eggs of Fundulus.* MARY J. GUTHRIE, University of Missouri. (Introduced by W. C. Curtis.)

This report is the first of a series on yolk formation in representative vertebrates. These are cell-physiology studies, using the methods of microchemical technique, and were undertaken to test the validity of the hypothesis that cytoplasmic inclusions are to be interpreted as end products of, or stages in, cell metabolism.

Ovarian eggs of *Fundulus heteroclitus* and *F. majalis* were used. Visible evidence of increased activity of the egg is apparent only after the formation of the follicle. Nuclear extrusion occurs at this time and, coincident with it, increase in cytoplasmic mass and very marked additions to the number of mitochondria which are often found as rows of granules. Following this, a single row of vesicles of unsaturated yolk appear at the periphery of the cell, and continue to be formed until they are found throughout the cytoplasm. Deposits of neutral fat are seen near the nucleus at this period, and heavy deposits of nutrients are observed in the inner region of the follicle. At the time when these formed reserves begin to pass from the follicle through the egg membrane, the mitochondria and neutral fat deposits decrease, saturated yolk is precipitated between the vesicles of unsaturated yolk, and unsaturated yolk is transformed into saturated yolk. Neutral fat is utilized in the latter process. The mature egg consists of a central region of saturated yolk in which neutral fat drops occur, surrounded by a zone of less saturated yolk. A thin peripheral layer of cytoplasm contains numerous mitochondria.

22.² *Storage of food in the eggs of reptiles.* MARY J. GUTHRIE AND DONALD F. ROBERTSON, University of Missouri. Reported by Mr. Robertson. (Introduced by W. C. Curtis.)

This report is chiefly based on developing ova in *Sceloporus undulatus*. Before the appearance of the follicle, mitochondria are perinuclear in position. With the formation and differentiation of the follicle the cytoplasm increases in amount, more abundant mitochondria are distributed in masses and strands throughout the cell, and neutral fat drops are precipitated. Certain cells of the follicle are very active metabolically, contain dense mitochondrial masses,

and have direct communication with the ovum. Extrusion of material from the egg nucleus follows, and, coincident with it, activity of the follicle cells in the elaboration of reserves is decreased. Within the egg heavy deposits of neutral fat are formed around the central region in which unsaturated yolk is being laid down. Saturated yolk is precipitated in a subperipheral zone. Neutral fat deposits are utilized in the transformation of unsaturated to saturated yolk. In the mature egg saturated yolk fills the central region which is surrounded by a zone containing unsaturated yolk and neutral fat, and the thin layer of peripheral cytoplasm is packed with mitochondria.

Observations on food storage indicate that deposition of nutrients occurs under nuclear influence. The progress of storage is first indicated by increased precipitation of mitochondria, which is followed by deposition of neutral fat and unsaturated yolk. Finally, saturated yolk is formed by direct elaboration within the cytoplasmic emulsion and, also, by transformation of unsaturated yolk. Cytoplasmic inclusions of the developing egg are interpreted as intermediate stages and end products in the metabolism of food storage.

23.¹ *Number and behavior of the chromosomes in Cavia cobaya (the common guinea-pig).* MARY T. HARMAN AND FRANK ROOT, Kansas State Agricultural College.

Material from two male guinea-pigs was used for this study. One of these animals was superactive sexually and the other was a normally active male. It was found that: 1) The actively dividing cells were not distributed throughout the whole lining of the seminiferous tubules, but were limited to elliptical areas. 2) These areas never exceed two-thirds of the circumference of the tubule and sometimes consist of only a few cells. 3) The largest diameter of the ellipse is always lengthwise of the tubule. 4) The areas of actively dividing cells are more numerous and larger in the superactive male. 5) There are thirty-eight spermatogonial chromosomes. 6) According to size and shape, the spermatogonial chromosomes may be arranged in eighteen similar pairs and a pair unequal in size which we have designated the XY-pair. 7) Both the primary and the secondary spermatocyte cells have nineteen chromosomes. 8) The XY-tetrad is precocious in its division, and the resultant chromosomes are unequal in size. 9) All the chromosomes divide equally in the second division.

24.¹ *The chromosomes of Doctor Nabour's parthenogenetically produced Tetrigidae.* W. R. B. ROBERTSON, University of Missouri.

Bisexually produced females show germ cells and somatic cells having fourteen chromosomes. In these cells the seven pairs of homologous chromosomes are readily recognized by their relative lengths. A member of any chromosome pair in such bisexually produced individuals may occur anywhere in the metaphase plate regardless of the position of its mate.

In a parthenogenetically produced female the cells show division figures with seven unpaired chromosomes and also figures with fourteen chromosomes. In the cells with fourteen chromosomes the members of a pair lie together or near each other in the complex. Sometimes the members of a pair, or of some pairs, are incompletely separated or connected in some way so that the appearance of there being less than fourteen chromosomes is given.

Nabours' breeding work and the above observations seem to warrant the inference that the parthenogenetically developing egg must have gone through its maturation division, resulting in a pronucleus with seven unpaired chromosomes, and that on its development, in some of the cleavage cells, probably of the preblastoderm stage, the duplex number of chromosomes must have been established by a fission of the seven unpaired chromosomes followed by a reorganization of a nucleus which included both daughter groups of chromosomes. In other cleavage cells it might be supposed that the daughter groups had formed separate nuclei and, of course, with seven chromosomes. The result when such cleavage cells should reach the outer layer of the egg and form the blastoderm would be a mixture of seven- and fourteen-chromosome cells.

25.¹ *The chromosomes in the cells of the embryonic membranes in the India runner duck.* MRS. ORILLA WERNER, University of Missouri. (Introduced by W. R. B. Robertson.)

The material used is from eight embryos of from eight to twelve days' incubation, and has been fixed and prepared by the Allen-Painter technique for mammalian chromosomes. The sex of the embryos was determined by a study of the primitive germ cells in the gonads, guided by the work of Swift on the chick.

There are probably seventy-six chromosomes in the cells of the male and seventy-seven chromosomes in the cells of the female, although it is extremely difficult to be certain about some of the smallest in the complex. The count has been made from late prophases and from metaphases. Among this large number of chromosomes there may readily be recognized five pairs of large chromosomes in the male and five pairs plus an unpaired chromosome in the female. Following these, there is a graduated series of twenty-two pairs which may also be distinguished in the complex. The remaining twenty-two chromosomes are so small and so closely graded in size that it is impossible to pair them.

In late prophases ten of these chromosomes, belonging to the intermediate sizes, seem to be connected end to end by interchromosomal filaments in such a way as to form two chains of five chromosomes each and consisting each of a similarly arranged series of unlike chromosomes. The corresponding members in each chain seem to be much alike.

PROTOZOOLOGY

(To be read at New Haven.)

26.² *A study of Lophomonas blattarum, a flagellate inhabitant in the colon of Blatta orientalis.* R. KUDO, University of Illinois. (5 min.)

Of 1400 *Blatta orientalis* studied, 32 per cent harbored *Lophomonas blattarum* Stein. The females showed a far greater number of flagellates than the males. The largest incidence was noticed in the summer months. The trophozoite possesses a remarkable power of locomotion and of change of form. Frequently a small nucleated portion breaks off completely from the anucleated main part of the body. The food consists mainly of starch grains. No cytostome is present.

²Author still uncertain on November 20th of the possibility of attending the meetings.

The food matter is taken in through the entire body surface except the anterior extremity. The axial structure is a bundle of axial filaments, each of which is continuous with the anterior flagellum. Its anterior end forms a calyx which encases a nucleus. Parabasal apparatus, which seems to be a protective organelle of the nucleus, is located round the calyx. Each flagellum passes through an elongated blepharoplast. The nuclear division is mitotic in which ordinarily six chromosomes and spindle fibers become prominent. A part of the blepharoplast ring becomes attached to the nuclear wall and forms a paradesmose which was sometimes called central spindle and which surrounds the daughter nuclei. Old calyx, bundle of axial filaments, blepharoplasts, flagella-tuft, and parabasal apparatus become absorbed by the cytoplasm. Binary fission was observed only. In cysts the nuclear division is similar to that of the trophozoite. In the second division, however, there appear ordinarily three chromosomes. Cysts with more than four nuclei were not seen. The flagellate is one of the commensals of the cockroach.

27.² *Division of Endamoeba blattae*. R. Kudo, University of Illinois. (5 min.)

The incidence of *Endamoeba blattae* among 1255 *Blatta orientalis* studied varied from 5 per cent (in March) to about 50 per cent (in summer months). This is related to the food habit of the insect, which is largely influenced by the atmospheric temperature. The amoeba possesses a remarkable appearance and structure. It contains usually a single nucleus. Of several thousands of living trophozoites observed from one to five hours at various times of the day, I saw in only two individuals complete process of nuclear division. One of these was a large active trophozoite. The observation was begun at 2 P.M. At 4.03 P.M. I noticed unusual brownian movements of the peripheral granules of the nucleus. At 4.10 P.M. the nucleus became oval and, four minutes later, greatly elongated. At 4.20 P.M. a constriction set in in the middle of the elongated nucleus. Five minutes later, the nucleus showed an appearance of a dumb-bell. At 4.29 P.M. cytoplasmic constriction started and at 4.48 P.M. apparently completed. At 5.10 P.M. the two uninucleated daughter amoebae became distinctly separated from each other. Thus the time required for the nuclear division in this individual was approximately thirty-eight minutes and that needed for the cytoplasmic constriction about nineteen minutes. In the second specimen, which was a small uninucleated trophozoite and which was in all probability in preecystic stage, the nuclear division, which was similar to that mentioned above, was completed in ten minutes without being accompanied by cytoplasmic constriction.

28. *The relation of rhythms to nutrition and excretion in three species of Paramecium*. W. BYERS UNGER, Dartmouth College. (Introduced by L. L. Woodruff.) (Lantern; 8 min.)

A study of pedigree cultures of *Paramecium aurelia*, *Paramecium calkinsi*, and *Paramecium caudatum* has shown that fluctuations in nutrition and excretion as indicated by food-vacuole formation and contractile-vacuole pulsation are coincident with the well-established rhythms in reproductive activity. Species which do not undergo endomixis exhibit these rhythms as well as species which do undergo endomixis.

Under similar conditions, the contractile vacuoles of *P. aurelia* and *P. caudatum* pulsate more rapidly than those of *P. calkinsi*. On the average, the posterior contractile vacuole pulsates more rapidly than the anterior in *P. aurelia*; in *P. calkinsi* the vacuoles pulsate at the same rate, and in *P. caudatum* the anterior vacuole contracts more rapidly. On the average, *P. calkinsi* and *P. caudatum* form more food vacuoles than *P. aurelia*, while the average size of food vacuoles is largest in *P. aurelia* and smallest in *P. calkinsi*.

In all three species more food vacuoles are formed at the top of rhythms than at the bottom, and the proportionate number of food vacuoles of a given size for a given species is almost identical at high and low points of curves for nutritive activity.

Although it is possible that racial variation of the phenomena studied may exist, it is believed that the data presented contribute toward a differentiation of three species of the genus *Paramecium* on the basis of physiological characters.

29.² *The interrelations of protozoa and the utricles of Utricularia.* R. W. HEGNER, Johns Hopkins University. (8 min.)

Various protozoa have been found in the utricles (bladders) of *Utricularia*. Experiments were carried on with certain rhizopods, flagellates, and ciliates. *Paramecia* were captured by about 30 per cent of bladders immersed in *paramecium* cultures within an hour, the number captured depending on the physiological condition of the bladder and the activity of the *Paramecia*. *Paramecia* usually died within the bladders in an average period of about seventy-five minutes. Some of them lived for many days in mature bladders, and all of them lived for many days in mature bladders previously killed by heat and in old dead bladders into which they were injected.

Paramecia usually disintegrated within several hours after capture. The principal conclusions from these studies are: 1) organisms do not force their way into bladders, but are captured by them; 2) the bladders do not select their prey, but any organism small enough to enter the vestibule may be captured; 3) organisms as small as *Chilomonas paramecium* (24μ in length) may be captured; 4) the protozoa found in the bladders are not intruders, but captives, and are probably all free-living species, and, 5) some of the captured protozoa live successfully within (*Euglena*, *Heteronema*, *Phacus*), some slowly starve to death (*Centropyxis*), and others are more or less quickly killed and digested (*Paramecium*, *Stentor*, *Stylonychia*, *Colpidium*). The data presented indicate that the bladders secrete something that kills and digests *paramecia*, but does not injure *euglenas*.

30.² *Host-parasite relationships in Coccidiosis.* JUSTIN M. ANDREWS, Johns Hopkins University. (Introduced by R. W. Hegner.) (7 min.)

Course of the infection in cats: Kittens under 600 grams, not previously infected with *Isospora felis*, succumb within seven days when inoculated with 100,000 or more viable oocysts. Similar kittens inoculated with smaller numbers showed intestinal symptoms within three days. Fresh oocysts were discharged within a week of inoculation. Discharge of oocysts continued for ten to thirty-six, usually about thirty, days. Animal recovers, sustaining only a transient inhibition to growth processes, but cannot be reinfected.

Host-parasite specificity: . . Oocysts of rabbit coccidia, *Eimeria stiedae* and *E. perforans*, are not infective to the cat or dog. The finding of many rabbit oocysts in the faeces of cats and dogs suggested that they were not affected by digestive processes in the foreign host as speedily as the normal parasites. Cotton sacks containing, separately, oocysts from the cat and dog, and from the rabbit were suspended in the stomach and duodenum of cats and dogs, and were recovered at varying intervals for examination. Evidences of digestive action on the normal coccidia of cats and dogs preceded similar appearances in the rabbit coccidia by approximately twenty-four hours. This suggests that a part of the mechanism of host-parasite specificity is due to the phenomenon of differential digestion, in the same period of time, of normal and foreign parasites.

31. Morphology, fission, and conjugation of the Balantidium from the guinea-pig.

MIRIAM J. SCOTT, University of Pennsylvania. (Introduced by D. H. Wenrich.) (Lantern; 15 min.)

Observations indicate this *Balantidium* from the guinea-pig to be *Balantidium coli*. Neiva et al ('14) described a *Balantidium* from this host and named it *Balantidium caviae*.

Balantidium coli is said by McDonald ('22) to range in length from 60 to 126 μ and in breadth from 39 to 90 μ . Present studies give ranges in length from 49 to 105 μ and in breadth from 33 to 92 μ . *Balantidium caviae* (Neiva) ranges from 60 to 90 μ in length and from 50 to 70 μ in breadth.

Plotting the body lengths of the parasites from one host, a bimodal curve resulted. Many of the group of smaller individuals were conjugants or ex-conjugants.

The comparative morphology of *Balantidium coli* and the *Balantidium* now under study corroborates the above evidence for the specific identity of the ciliates from the two hosts. Many of the ex-conjugants possess a spherical nucleus as Neiva represents for *Balantidium caviae*.

During fission, meganuclear division is preceded by the division and migration of the micronucleus.

In conjugation, a degeneration of the meganucleus begins with the union of the conjugants. The micronucleus divides twice. Three of these nuclei degenerate, while one divides. An exchange of the migratory nuclei follows, and the conjugants separate. The new meganucleus and micronucleus develop from the fertilization nucleus.

Some experimental work has also been done concerning body and cellular changes produced by culture media and fixation processes.

32. The intestinal protozoa of termites. HAROLD KIRBY, JR., Yale University. (Introduced by L. L. Woodruff.) (Charts; 7 min.)

Wood-feeding termites support remarkable intestinal faunas of polymastigote and hypermastigote flagellates. During a recent trip to Central America preparations were made from fifteen species in ten genera of termites of the lower families. Protozoa have not previously been described in the Termitidae. Cleveland ('23) recorded an infection in *Mirotermes*; this was found to be a large, wood-feeding amoeba, providing the first record of amoebae in termites. Small

amoebae were found also in two *Amitermes*, and small flagellates in these and several other *Termitidae*; but these are presumably parasitic or commensal forms, not aiding in wood digestion. The *Kalotermitidae* generally contain five to seven species of flagellates each, but a few have only one or two. These range from simple trichomonads and other *Tetramitidae* to *Devescovina*, *Macrotrichomonas*, the large multinucleate *Calonymphidae* and complex *Trichonymphidae*. An interesting group is the *Oxymonas* series, which includes the usual small, uninucleate, axostylate form and the large multinucleate flagellate of *Cryptotermes dudleyi*. A close relationship is evident among congeners of Central American and West Indian termites, but *Kalotermes minor* shows a marked difference from these, indicative of a remote derivation. Whereas most *Kalotermes* contain *Trichonymphidae*, this substitutes the equally complex but unrelated *Stauroioenina*, a genus described from eastern Africa and comprised in a group, the *Joenidae*, present in African, European, and Asian termites, but unknown in the Floridian, West Indian, and Central American termites so far studied. There is also a relation between the flagellates of a *Kalotermes* species, which differ somewhat from those of its congeners in Central America, and those of *Kalotermes* species from the Galapagos and Fanning Islands in the Pacific. A suggestion is thus given of the light to be thrown on the derivation and distribution of termites through a study of the intestinal faunas.

By title

- 33.¹ *The effect of excisions on amoeba.* LILLIAN A. PHILPS, Cornell University.
(Introduced by A. A. Schaeffer.)

Division in *Chaos diffuens* (= *Amoeba proteus emend.*) seems to be a direct result of increase in size of the cytoplasm, and at the same time the rate of growth is definitely retarded by the act of excision and consequent regeneration. After successive excisions of the largest amounts possible of the amoeba's cytoplasm, the nucleus becomes reduced in size to accommodate itself to the decreased amount of cytoplasm. Successive excisions of one-quarter of an amoeba's cytoplasm (for thirty-two days) has no effect on subsequent divisions.

The smallest minimal reorganization mass obtained thus far in the experiments is 1/80 as large as the original amoeba, which is somewhat smaller than the smallest minimal reorganization mass heretofore obtained in the protozoa.

The number of crystals present in the cytoplasm appears to be a good index of metabolic changes in the amoeba and perhaps in other protozoa.

- 34.¹ *Taxonomy and evolution of the amoebas.* A. A. SCHAEFFER, University of Kansas.

Amoebas can be classified satisfactorily on the basis of gross morphology. The larger species are readily recognized by one or two outstanding external characters.

The principal families of the amoebas are the *Trimastigamoebidae*, *Chaidae*, *Mayorellidae*, *Hyalodiscidae*, *Thecamoebidae*, and the *Endamoebidae*.

The *Trimastigamoebidae* comprise those amoebas which have an adult flagellate stage. The *Chaidae* form indeterminate pseudopods (pseudopods through which the whole amoeba may flow) or consist in effect of one indeterminate pseudopod.

The Mayorellidae possess determinate pseudopods (of small and limited size). The Thecamoebidae are flattened, roundish amebas in outline without pseudopods, but with longitudinal ridges on the ectoplasm. The Hyalodiscidae move by means of a thin sheet of protoplasm surrounding a large central mass of granular protoplasm which does not take part in locomotion. The Endamoebidae do not move coordinately and are parasitic in habit.

There is reason to believe that the Trimastigamoebidae are the most primitive of the amebas, if the monophyletic hypothesis is adopted. The next group in order of differentiation are the Chaidae, from which, perhaps at several points, many of the Endamoebidae have come. Next in order of increasing differentiation may come the Mayorellidae, the Thecamoebidae and the Hyalodiscidae. It is possible that these three families arose independently from a lower group. There is as definite evidence for general morphological evolution among the amebas as in many other groups of organisms.

35.¹ *Life-history of Prorodon griseus.* G. W. TANNREUTHER, University of Missouri.

Prorodon griseus, a holotrichous ciliate, is found in great numbers in small rain pools. But, on account of the sudden drying up of these pools after each rain, the animals pass the greater part of their life-cycle in the encysted state. Collections were made of the free and the encysted forms and placed in finger-bowls with tap-water, in order to determine the nature of their activities during the cyclic stages under laboratory conditions. The life-cycle required from six to eight days for its completion. When collected, as a rule, the animals were in the encysted stage, but most of the forms escaped from the cysts within twenty-four hours. This was immediately (within one or two hours) followed by an epidemic of conjugation, which lasted about six to seven hours at most. The exconjugants remained in the free-swimming stages (active binary fission and feeding period) five or six hours and then encysted. They remained in the cysts from five to six days and then escaped, thus starting a new cycle. Binary fission and conjugation (except the early fusion of the conjugants) may occur either within the cysts or in the free forms. Cytoplasmic without nuclear reorganization occurs during encystment. The cysts serve more for protection, reproduction, and reorganization.

36.¹ *Life-history of Chilodon cucullulus Ehrenberg.* G. W. TANNREUTHER, University of Missouri.

Chilodon cucullulus, a fresh-water ciliate, is found quite abundantly in rain pools in the vicinity of Columbia, Missouri. The single micronucleus divides mitotically and the macronucleus amitotically during binary fission and conjugation. The activities of the micronucleus in conjugation for the most part confirm Enriques and MacDougall's report as found in *Chilodon uncinatus*. There is a distinct macronuclear exchange in conjugation, comparable to that of the micronucleus. There is a single division of the fertilization nucleus in the formation of the new micronucleus and the new macronucleus.

There are two distinct periods of reproduction by binary fission—one immediately preceding conjugation and the other immediately following conjugation.

The conjugants are more of the medium-sized individuals, varying from one-half to three-fourths of the maximum-sized forms. The conjugants may feed during early and late conjugation. The ex-conjugants, however, feed but little during their active period of binary fission; as a result, they are reduced to about one-sixth of the size of the original ex-conjugants. These small forms become quiescent, lose their cilia and pharynx, and become encysted. When recovered from the cysts, these small forms gorge themselves with food, and in four or five days reach the adult condition and begin a new cycle. Encystment serves more for protection, and not for nuclear reorganization.

37.¹ *Growth of Paramoecia in pure cultures of Pseudomonas pyocyaneus.* CHARLES H. PHILPOTT, Harris Teachers College. (Introduced by W. C. Curtis.)

A race of paramoecia grows at a high division rate in young cultures of *Ps. pyocyaneus* and is able to acclimate itself to the toxicity of older infusions.

Pyocyaneus infusions are made by daily inoculating quantities of 0.2 per cent sterile hay water and incubating at 32°C. In pyocyaneus infusions, incubated two days, paramoecia show constantly a higher division rate than in the control, chance-mixed bacterial infusions. Ten-day pyocyaneus infusions, however, are toxic to paramoecia; but, by providing a period of recovery from the effects of the toxicity, the race of paramoecia becomes acclimated to the ten-day infusion and continues to grow in it at a higher division rate than in the control, mixed bacterial infusions. It is found, furthermore, that paramoecia, which have previously grown in two-day pyocyaneus infusions, do not show the usual depression from toxic effects when transferred to ten-day pyocyaneus infusions.

All animals used in the experiments are descendants of one individual. Daily-isolation culture methods are used to insure uniparental inheritance. The paramoecia are sterilized by transferring with sterile pipettes through a number of sterile waters following the methods of Hargitt and Fray ('17) and of Phillips ('22). Growth in pyocyaneus infusions is accomplished by the use of drop-culture slides in sterile Petri dishes.

38. *Properties of the reproduction-inhibiting reaction product in infections with Trypanosoma lewisi.* W. H. TALIAFERRO, University of Chicago.

Infections with *T. lewisi* in the rat are characterized by complete cessation of reproduction of the parasites after about the tenth day. The present author has shown that this is due to the formation in the rat of a reaction product which inhibits the reproduction of the trypanosomes without killing them or apparently affecting their vitality (Jour. Exp. Med., vol. 39, pp. 171-190). As this is probably a previously unknown effect of resistance, investigations have been extended to ascertain in what respect this reaction product resembles those previously described, such as lysins, etc. It behaves like most known immune bodies in that the reproduction-inhibiting property is precipitated in the globulin fraction of the serum (partly in the euglobulin and partly in the pseudoglobulin). It differs from these, however, in its affinity for its supposed antigen. If large numbers of dividing *T. lewisi* are left in contact with the immune serum and then removed by centrifugation, the immune serum does not diminish in titer,

PARASITOLOGY

(To be read at New Haven.)

39.² *Microsporidia in the mosquitoes of Georgia.* R. KUDO, University of Illinois.
(5 min.)

In the summer of 1923, a study was undertaken in Georgia to determine the natural occurrence of Microsporidia which I had observed in various parts of the United States, among the anopheline mosquitoes (*Anopheles quadrimaculatus*, *A. crucians*, and *A. punctipennis*). Of the examined larvae, which were mostly the first-named species, 4.5 per cent were found to be infected by microsporidia. Of fifty-four parasitized by *Thelohania legeri*, the commonest anopheline parasite, thirty were so heavily infected that the effect was apparently fatal to the hosts. The fact that adult anopheline mosquitoes become infected by the species of microsporidia which occur in the larvae indicates that, when the infection is not severe, the larvae reach the adult stage. Infection experiments show that the larvae become infected per os. Three new species attacking the anopheline mosquitoes and two new species occurring in the culicine mosquitoes were observed. These microsporidian parasites of mosquitoes are specific to the genera of the host insects, although the larvae of both genera were found living side by side in small bodies of water.

40. *A new semiparasitic copepod of the family Clausidiidae.* CHARLES H. BLAKE, Massachusetts Institute of Technology. (Introduced by R. P. Biglow.)
(Charts; 10 min.)

Specimens of both sexes of a new member of the family Clausidiidae to be called *Hersiliopsis welshi* gen. et sp.n. were taken from an *Arenicola cristata* from North Falmouth, Massachusetts. The species has the characters of the genus which is distinguished from the allied *Giardella* Canu by the body form and the structure of the mouth-parts. The author indicates that Sars's view of the mouth-parts in this family is correct. The nauplius of the species is described.

By title

41.² *Studies on the effect of parasitism upon the tissues. II. With special reference to a new diplostomous trematode found in the minnow, Notropis anogenus Forbes.* H. P. KJERSCHOW AGERSBORG, James Millikin University.

In the first place, the effect on normal metabolism of the organ tissues of *Notropis anogenus* by the presence of *Diplostomum van cleavei* in its coelomic cavity is tremendous. Only three trematode larvae are sufficient to upset metabolism. There are several marked symptoms: The minnow swims with spasmodic, asymmetrical strokes, and sometimes whirls in a circle; it loses its balance and the right or left side becomes uppermost; it becomes filled with gas; it comes to the surface and gasps for air, which it seems to swallow. This may be characterized as a strangulation period. While gasping for air at the surface, it may become relieved; if not, it succumbs. In dead individuals, the peritoneum is exceedingly delicate, as if it had become decomposed. This condition is the same in infected individuals, opened alive. The liver, in infected individuals, is far more delicate than in uninfected ones; post-mortem decomposition is much more rapid in parasitized minnows than in non-infected ones.

In the second place, the habitat of *Diplostomum van cleavei* (sp. nov.) is the coelomic cavity of the fresh-water minnow, *Notropis anogenus* Forbes, which lives in the drainage ditch of Crystal Lake, Urbana, Illinois. *D. van cleavei* aggregates particularly around the liver of its host. It has also been found by Professor Van Cleave on the air bladder of the blue sunfish, *Lepomis pallidus* (Mitchill). Its somatic characteristics differ markedly from those of other species so far described. They inhabit some portion of the alimentary canal, notably the intestine, of higher vertebrates.

42. *Larval trematodes from Dry Tortugas.* HARRY M. MILLER, JR., Washington University. (Introduced by Caswell Grave.)

A survey of various species of mollusks from the Dry Tortugas has been made, with a view to determining the degree and character of the larval trematode infestation. During six weeks of June and July, 1925, 4341 mollusks, belonging to thirty-three genera and fifty species, were examined; nine species, eight of which were gastropods, harbored larvae, with degree of infestation ranging from 0.2 to 20 per cent. Only 1 per cent of all individuals was infested. Thirteen, and possibly fifteen, species of trematodes were found: four or five cotylicercous distomes, three gymnocephalous distomes, one huge-tailed monostome, a stylet, a cystophorous, a trichocercous, a gasterostome, and an echinostome cercaria, and in addition an unidentified sporocyst. Each was found to be specific to its molluscan host, unless the two similar cotylicercous cercariae are shown by further study to be identical. Seven were found on a single occasion only. *Cerithium litteratum* was the most interesting host, in that 17 per cent of all individuals was infested and four different cercariae were found. The positive phototropism of the huge-tailed monostome was marked; only one other larva, the trichocercous distome, reacted strongly to light, in this case negatively. The remaining ones appeared indifferent to daylight.

43.¹ *Ectoparasitic Infusoria attacking fish of Pacific Northwest.* JOHN E. GUBERLET, University of Washington.

Three species of ectoparasitic Infusoria, *Cyclochaeta Domerguei* Wallengren, *Chilodon cyprini* Moroff, and *Ichthyophthirius multifiliis* (Fouquet), were observed to be the causative factors of destructive diseases of fish in aquaria and hatchery ponds of the Pacific Northwest. *Cyclochaeta Domerguei* and *Chilodon cyprini* were demonstrated to be the cause of an epidemic in aquaria containing tench, catfish, crappie, suckers, carp, and stickleback. Salmon, trout, and perch were not attacked when placed in aquaria with affected fish. Both species of Infusoria were present on the fishes at the same time, but display a seasonal distribution. Temperature plays an important rôle in relation to the seasonal distribution of both *Cyclochaeta* and *Chilodon*. *Cyclochaeta Domerguei* develops best and is most destructive to fish when the water is cold, 42° to 50°F, while *Chilodon cyprini* becomes numerous in the same aquarium when the temperature rises considerably above 50°F. It was observed that with the elevation of temperature in the spring *Cyclochaeta* gradually decreased in numbers, became inactive and sluggish, while *Chilodon* increased in numbers and activity. During the present autumn the reverse is true as the temperature of the water is lowering. *Ichthyophthirius multifiliis* was the cause of serious loss of fry and fingerlings of cut-throat trout, *Salmo mykiss*, in hatchery ponds.

Baths of fifteen to twenty minutes' duration at intervals of two or three days in a 2 per cent common salt solution proved effective against *Cyclochaeta* and *Chilodon*, while keeping the fish in rapidly running water served to keep *Ichthyophthirius* under control.

44.¹ *The cestodes of the rhinoceroses.* HORACE W. STUNKARD, New York University.

Abundant material of a cestode from the white rhinoceros, *Ceratotherium cottoni*, has been identified as *Plagiotænia gigantea*. This species was first described by Peters ('56) from the black African rhinoceros, *Diceros bicornis*, and thus infests both African rhinoceroses. Study of this material shows that the generic name *Plagiotænia* is valid and demonstrates also that the forms from the Javanese rhinoceros, described as *Plagiotænia gigantea* by Garrod ('77) and MacCallum and MacCallum ('12), are not members of the species, *Plagiotænia gigantea*. Four different species of tape-worms are then known from the four different rhinoceroses. Some of the specimens of *P. gigantea* are completely sterile, others have gravid terminal proglottids, while those near the scolex are sterile, and many have fertile segments near the scolex with sterile terminal proglottids. Sterile proglottids have been reported by many authors as frequent among the anoplocephaline tapes. It seems probable, in the rhinoceros cestodes at least, that the first-formed segments are sterile, that after later the reproductive capacity is exhausted with the formation of only sterile proglottids.

45.¹ *A new blood fluke, Unicaecum ruszkowskii n.g., n.sp.; a contribution to the relationship of the blood-infesting trematodes.* HORACE W. STUNKARD, New York University.

A new blood fluke has been found in *Pseudemys scripta* from the southeastern United States which throws additional light on the problem of the blood-infesting trematodes. A new genus *Unicaecum* is created to contain these worms for which the specific name *ruszkowskii* is proposed. The specimens are 6 to 8 mm. long, 0.5 to 0.96 mm. in width, and 0.2 to 0.4 mm. in thickness. The musculature is weak; acetabulum and pharynx, absent. Esophagus surrounded by secretive cells. Digestive system consists of a single cecum, which extends almost to posterior end of body. Testes form continuous lobed column in center of body; vas deferens arises from anterior end and passes backward in sinuous course. Cirrus sac and cirrus present. Genital pore ventral, sinistral, near posterior level of testis. Ovary long, coiled, situated in posterior third of body; oviduct arises from posterior end, passes backward to ootype, and uterine duct leads forward to genital pore. Seminal receptacle and Laurer's canal absent. Vitellaria consist of irregularly distributed follicles extending from level of esophagus to ootype. Eggs large, thin-shelled, spherical, discharged singly.

This form undoubtedly belongs in the family Spirorchidae, although the family diagnosis must be emended to contain it. In details of structure these worms manifest similarity to the schistosomes and present further evidence to support the idea of the genetic relationship of the blood-inhabiting flukes.

COMPARATIVE ANATOMY

(To be read at New Haven.)

46. *Anatomy of Hendersonia, a primitive helicinid mollusk.* H. BURRINGTON BAKER, University of Pennsylvania. (Lantern; 15 min.)

Hendersonia retains a right (prosobranch) auricle and a metamorphosed right kidney (provagina) in both sexes, and thus apparently represents the most primitive known condition in the Helicinidae (Gastropoda rhipidoglossa). As regards the first of these characters, it is fully as generalized as any known Neritid, while, in the second, it appears even less specialized. Also, in the uncinate form of the third lateral of the radula and in the posterior position of both external ureteric openings, most Helicinidae share these more primitive conditions; for these reasons, the Neritidae cannot be considered as in any sense ancestral to the Helicinidae. On the other hand, the marine and fresh-water habitats of most Neritidae have permitted them to retain certain markedly primitive characters, while the terrestrial life of the Helicinidae is coincident with increase in specialization along several lines, all of which center around the notable elongation of the dorsal region and pallial cavity, correlated with the conversion of the latter into a lung. In this last category of Helicinid characters fall the rotation of the heart and kidney, the comparative freedom of the ventricle from the looped hindgut, the separation of the pericardium and right kidney (provagina), the apparently complete reduction of the supra-intestinal ganglion and its connectives, and the relative elongation of the hindgut, the secondary gonoduct, the oesophagus, and the nerve strand between the subintestinal and abdominal ganglia.

47. *The occlusion of the digestive tract in reptiles.* ALBERT M. REESE, West Virginia University. (Lantern; 10 min.)

The temporary closure of a part of the anterior region of the digestive tract is commonly observed in the various classes of vertebrates in early embryonic life.

The closure usually takes place at about the time of the closure of the gill clefts in those forms in which the latter structures are transitory.

The closure may include not only a considerable portion of the oesophagus, but also the extreme anterior end of the trachea.

In the alligator the oesophagus regains its lumen, but remains separated, by a thin partition, from the pharynx until almost the time of hatching. The trachea reopens into the pharynx at an earlier date.

In the snakes (moccasin and copperhead), as in the alligator, the trachea first regains its connections with the pharynx, while cavities of the pharynx and oesophagus are long, separated by a thick folded 'occlusion membrane.'

48. *The pigment bodies of the hair shafts of mammals, including man, and their relationships to species and to race.* L. A. HAUSMAN, Rutgers University. (Introduced by T. C. Nelson.) (Lantern; 10 min.)

Studies of the microscopic structure of the cuticular scales and medullas of the hair of mammals (including man) have shown that the characteristics of

structure of these elements bear an evident relationship not to species or natural groups of forms, but to the diameter of the hair shafts. Races of mankind, therefore, are not delimitable upon the basis of difference in hair-shaft structural elements any more than are species or other natural groups of mammals below man.

Studies of the form, color, and pattern of the pigment granules in the cortex and medulla of mammals below man show differences relatable to natural groups, often species. Among the races of mankind, black, or nearly black, hairs show pigment-granule differences from race to race; hairs of other colors appear not to do so. In general, the micrology, at present, of pigment granules points to a relationship of these elements with hair color, rather than with racial groups of mankind.

49. *The smallest sucking fishes (Echeneididae) on record.* E. W. GUDGER, American Museum of Natural History. (Opaque projection; 10 min.)

These fishes are distinguished from all other fishes by the possession of a cephalic sucking disk made of a transformed spinous dorsal fin. Of this family I have on hand the following diminutive specimens.

The smallest of these fishes ever captured is a Remora, 30 mm. long, taken in a net at the surface about thirty-five miles southeast of Cape Lookout in 1914. This fish, though so minute, is perfect in every respect, having no trace of larval structures. The next smallest Remora is a 47-mm. specimen taken by William Beebe on his first Galapagos expedition. The next smallest is a Rhombochirus 69 mm. long over all. This was taken from the gills of a sailfish, *Istiophorus gladius*, captured near Long Key, Florida, in 1924. This little fish, like the preceding, shows no trace of larval characters.

Of the genus *Echeneis*, numerous small specimens are known, but the exact size of the smallest cannot now be stated. It has been known since 1835 that the young of this genus have an elongated central lobe to the caudal fin, and this was figured by Günther in 1876. I have a large collection of young *Echeneises* from Key West from 100 mm. up which show the transformation of the tail down to the slightly lunate form characteristic of this genus.

Of the embryology of these fishes absolutely nothing is known. No eggs or larvae have ever been taken. There is a fossil form known, but in it the sucking disk is fully formed, perfect in every respect.

The larger article will contain figures and full data of all the known small sucking fishes.

50. *Autotomy in Arachnida.* FLORENCE DOWDEN WOOD, Loyola University Medical School. (Introduced by A. Petrunkevitch.) (Lantern; 10 min.)

Guided by an experimental study and by observations on the morphology of the legs of spiders, P. Friedrich described a cutting device within the trochanter which would sever the appendage from the body when the leg was stimulated by injury.

A reinvestigation of the problem yielded entirely contrary results. Experiments calculated to induce spontaneous amputation through an automatic reflex in the leg were negative on scorpions, harvestmen, and upward of a dozen species of spiders. A detailed morphological study of the skeleton and musculature

of the arachnid leg showed that no autotomizing device existed either in the skeleton or in the arrangement of muscles. In all species studied, excepting the scorpion, severance of the leg from the body occurred more readily at a given point. This point at which severance so readily occurred was shown to be directly correlated with a definite structural weakness in the skeleton and musculature. It was observed that the spider itself removed an injured leg by grasping the stump with its mouth parts. No such injured stump fell off spontaneously or without the application of external means. The scorpions do not autotomize appendages under any stimulation, nor do they show any anatomical weakness in the leg skeleton or musculature.

Autotomy as an automatic reflex does not exist in the Arachnida.

By title

51. *Possible scale vestiges in a urodele larva.* INEZ WHIPPLE WILDER, Smith College.

The surface of larvae of *Eurycea bislineata* appears from time to time thickly studded with mound-like elevations, comprising, as seen in superficial view, from eight to twelve cells. In rough correlation with the size of the individual, the mounds range from 46 to 76 μ in diameter and from 10 to 33 μ in height. Their arrangement in rows suggests that of the scales of a lizard. In some regions they are confluent, thus forming ridges. They are wholly epidermic in structure and show a large amount of mitosis, particularly in the outer of the two layers of cells of the typical larval epidermis. They gradually fade away, apparently as a result of the sloughing off of flaky patches of cells—a larval molting process. When the first multicellular gland anlagen appear (a metamorphic phenomenon) they seem to correspond to these mounds.

With the casting off of the last flaky molt before transformation, the character of the outermost layer of epidermic cells changes completely, and the cornified molt layer of squamous epithelial cells characteristic of the adult takes the place of the active, self-propagating external layer of cuboidal cells of larval life. The homology of this larval external layer with the epitrichium (periderm) which forms the original outer covering of developing scales in higher forms is obvious, and the mound-like epidermic structures are interpreted as the last vestiges of the epidermic thickenings which formed the outer covering of dermal scales in ancestral amphibian forms.

52. *The derivatives of the posterior cardinal vein in the rat.* MARTHA THOMPSON STRONG, Indiana University. (Introduced by F. P. Reagan.)

Structures generally designated in 10-mm. pig or in twelve-day rat embryos as posterior cardinal veins persist on the left side (in extent, one to three segments) to form the proximal portion of the hemiazygos. Unpublished work by F. P. Reagan shows posterior cardinals at this age to represent only in part the primitive posterior cardinal vessels which very early have been replaced superiorly, to an extent by ventromesial anastomoses between posterior cardinals and ducts of Cuvier. Thoracic hemiazygos is derived largely from a supra-cardinal plexus.

On the right side blood from segmental veins passes in the posterior cardinal at first superiorly to the heart, later temporarily into the inferior vena cava, either by way of posterior cardinal, supracardinal, or diagonally directed new segmentals.

According to Reagan, supracardinal vessels first arise as simple endothelial arches between the bases of segmental arteries and the bases of their accompanying veins; these arches become connected by capillary nets. Observations on rat-embryos lead also to such a conclusion.

Superior intercostals and lumbar vessels first arise as fusions between pre-existing segmental vessels lateral to the sympathetic trunks. They are neither supracardinal nor cardinal derivatives. In the orang-utan, R. Peers and L. Hamilton, working under the direction of Reagan, have found conditions similar to this. Reliable works on human anatomy, however, show superior intercostals mesial to the sympathetic trunks. This point of interest in human embryology is under investigation.

53. Certain features of vascular development as shown by injected rat embryos younger than mammalian embryos hitherto injected. FRANKLIN P. REAGAN, University of California.

Correlated with posterior migration of the primitive heart is the lengthening of the anterior cardinal vein. This takes place at the expense of the duct of Cuvier, rather than at the expense of the posterior cardinal or of the 'common cardinal' of Sabin. A portion of the primitive duct of Cuvier becomes incorporated into the anterior cardinal vein, whereas no part of the other structures mentioned become so transformed.

External jugular and internal mammary veins, ordinarily regarded as relatively late-appearing structures, can be found in embryos of twelve somites to enter the cephalic border of the cuvierian duct. Later, as this portion of the duct becomes incorporated into anterior cardinal, they appear to enter that vessel; they form a constant landmark with reference to which ventromesial 'migration' of posterior cardinal along the duct of Cuvier is readily determined.

Anlagen of internal mammaries apparently exist at a much earlier stage than twelve somites.

Plexuses including the external jugular anlagen drain early the posterior portion of the ventral aorta and the ventral ends of the various aortic arches successively.

Primitive omphalomesenteric artery is represented as a ventral and then forward prolongation of the dorsal aortae ventral to the hind gut. Only secondarily does its distal yolk-sac arterial stem acquire transversely directed connections with the dorsal aorta which (connections) later appear variously as roots of this distal yolk-sac portion, posterior to which the subintestinal omphalomesenteric degenerates.

Continuous vascular structures of two-somite embryos have been completely injected, as shown in subsequent sections.

54. *The nervous mechanism of respiration in elasmobranch fishes.* MARY GRACE SPRINGER, Barnard College, Columbia University. (Introduced by F. H. Pike.)

The functional organization of the neuromuscular respiratory mechanism in elasmobranchs comprises: 1) A central motor mechanism in the medulla. 2) Afferent fibers in the cranial nerves—maxillary fifth and tenth—and in the spinal nerves, together with their central end stations. The central end station of the vagus seems to have remained rather constant in the vertebrate phylum, while the functional importance of the fifth cranial and of the spinal nerves has shifted greatly. 3) The efferent path through the fifth, seventh, ninth, and tenth cranial nerves. There is no indication of an efferent path, so important in land breathers, in the spinal cord of elasmobranchs. The functional importance of the efferent path through the cranial nerves is greater in elasmobranchs than in higher representatives of the vertebrate phylum. The importance of afferent nervous impulses for the control of respiratory movements is clearly established in elasmobranchs, a summation of stimuli from the afferent nerves and from the dissolved gases in the blood being important in these forms. The central end stations in elasmobranchs include the caudal portion of the corpora bigemina, though it is the fifth nerves whose relations are most important in elasmobranchs as contrasted with the spinal nerves of mammals.

55. *The cranium of the pleuracanthid sharks, with special reference to Diacranodus.* L. HUSSAKOF, American Museum of Natural History.

The present study was undertaken in order to clarify our knowledge of the structure of the cranium in the pleuracanth sharks. It is based on the genus *Diacranodus*, found in the Permian formation of Texas; a fair-sized shark, with a cranium 6 or 8 inches in length, and hence much more favorable for study than that of the smaller, European *Pleuracanthus*.

Several nearly complete crania in the American Museum of Natural History enabled me to work out the external structural details almost as perfectly as from a fresh specimen. I also prepared a reconstruction, of which two reproductions in wax, one showing the dorsal, the other the ventral aspect, may be seen in the fossil fish exhibit at the American Museum.

The problem was cleared up of the mode of articulation of the large post-cranial spine—a specialization found only in the *Pleuracanthidae*. There is a large glenoid depression on the posterior face of the cranium in which the base of the spine was lodged.

The paper, with illustrations, will discuss all the important anatomical features of the cranium.

- 56.¹ *Innervation of the head muscles of the albino mouse.* W. A. WILLARD, University of Nebraska.

This is a partial analysis of the cranial nerves innervating the muscles of branchial origin in the mouse. It is based upon series of sections of the adult head treated by the pyridine-silver method after decalcification offering continuity of study from brain centers to end organs. Axons show their distinctive differences and may be followed to motor end plates or to neuromuscular spindles.

Some facts shown are, 1) innervation of the levator veli palatini and tensor tympani independent of any connection with the otic ganglion; 2) all other palatal muscles by the pharyngeal ramus of the vagus which is wholly motor; 3) that glossopharyngeal carries motor fibers to the styloglossus and hyoglossus muscles, preganglionic axons to a large sympathetic ganglion in the base of the tongue from which are supplied fibers to the numerous glands that surround the pharynx; 4) the relation of the other vagus rami to the laryngeal muscles; 5) the presence of encapsulated muscle spindles in the large masticatory muscles; and their apparent absence in other muscles of the branchial group, although easily demonstrated in muscles of the occipital region supplied by spinal nerves; 6) the distribution to blood vessels of the fine postganglionic axons carried in the motor rami with no distinct evidence of a sympathetic innervation to the striate muscle.

GENERAL EVOLUTION

(To be read at New Haven.)

57. *The nature of the struggle for existence from the point of view of the second law of thermodynamics.* F. H. PIKE, Columbia University. (10 min.)

Waiving the question whether the second law of thermodynamics is strictly applicable to the life-cycle of the individual or of the species, it is instructive to consider what one might expect in the phenomena of organic evolution if it did apply. On the basis of Lewis and Randall's statement of this law, "Every system, if left to itself, tends to assume a condition of maximum probability," one might expect that the condition of maximum probability for living organisms would be that they would immediately cease to exist. The great persistence of living matter in geological time shows that such an expectation is unfounded. Another expectation is that, in the course of development of the species, the processes necessary for the mere maintenance of life would tend to occur with the least expenditure of work—an expectation that seems justified. A second condition of maximum probability would be that the entrance of free energy of the environment into the life-cycle would be a spontaneous process. In this sense, organisms do not struggle for free energy, but this free energy flows through the life-cycle as the path of least constraint. The driving force in evolution is to be sought in the free energy of the environment, as it is here that variations and new characters have their source. Heredity and environment limit the range of variation which may occur.

ECOLOGY

(To be read at New Haven.)

- 58.² *A mussel survey of the upper Mississippi River.* N. M. GRIER, Dartmouth College, and R. H. YOUNG, Northwestern University Medical School. (Lantern; 15 min.)

Earlier wasteful methods of lumbering in Wisconsin and Minnesota caused the rivers of those States to discharge enormous quantities of sand into the upper Mississippi. In order that the channel be kept open, Government engineers

constructed wing dams along the river designed to catch the sand and build up the shore between the dams. The sand caught by the dams unfortunately smothered extensive beds of mussels already seriously depleted by improper fishing methods and stream pollution. These animals are the principal source of pearl buttons.

To conserve these natural resources, the States concerned passed protective laws in 1920, providing that certain sections of the river be open or closed to mussel fishery for the next five years, during which the efficacy of the protective laws could be tested. Under the auspices of the U. S. Bureau of Fisheries, the senior author made a survey and appraisal of the mussel resources in 1920, repeating this work during the past summer. The results indicate that conditions have become more unfavorable to mussel life and that these resources in the regions covered have declined with the present instability of the river channel, improper fishing methods, and pollution of the water as contributing factors.

59.² *Environmental factors in relation to distribution of Panamanian fresh-water fishes.* ELLINOR H. BEHRE, Louisiana State University. (10 min.)

The collection which forms the basis of this report extends the hitherto known limits of ten of the fourteen families found in this territory. Extensions of old limits are southward along the Caribbean coast, northward along the Pacific coast, paralleling the course of the original migrations.

Two new species are described, one marking a new northern limit for a whole South American family.

Caribbean and Pacific-slope fish faunas are almost entirely unlike. Of the forty-nine species found, thirty-six are Caribbean only, ten Pacific only, and three common to both slopes. These three are representatives of widely distributed brackish-water genera.

Only fourteen of the forty-nine species seem to be at all limited by altitudes between sea-level and 7000 feet. Of these fourteen, seven are common in brackish water.

The fishes seem independent of considerable variation in P_H . The waters tested ranged between P_H 6.8 and 8.4. All species found in waters of P_H 7.0 were also found at P_H 8.4. This is particularly striking in regard to the Pacific-slope fish fauna; the season of our collecting was 'dry,' and the ranges of P_H the widest that we observed, yet the species almost universal in distribution.

By title

60. *Ecological studies on gastropods.* E. P. CHEATUM, Southern Methodist University. (Introduced by S. W. Geiser.)

Studies were made on the behavior of land snails regarding the importance of humidity as an environmental factor. Nocturnal activity is believed to be associated with humidity, since the beginning of feeding activities is coincident with dew, rather than darkness, and feeding continues far into the morning after a rain. Also the same species of snails observed on the same night showed activity in proportion to the humidity of their environment, and at the same temperature, emergence in the spring did not occur in the absence of moisture.

Experiments were carried out on the overwintering of two species of aquatic pulmonates, *Pseudosuccinea columella* casta Lea and *Physa gyrina* Say. Both species were taken living from under ice and were observed to emerge from under ice in the spring, but were killed by experimental freezing in a block of ice. Both species, when retained under water in wire baskets for a period of eight months, were found to live normally and deposit eggs. Upon examination, air was always found in the lung chamber.

Polygyra thyroides (Say), *Helix troostiana* (Lea), and *Pyramidula alternata* (Say) sealed apertures when subjected to low temperatures as well as to high temperatures. The length of time required for complete closing of the aperture varied directly with the temperature (range, 2° to 40°) to which the three species were subjected.

61.¹ *A study of the nutrition of wood-boring mollusks.* ROBERT C. MILLER, University of Washington.

An experimental study has been made of the nutrition of two species of wood-boring mollusks, *Teredo navalis* and *Bankia setacea*. Analysis of wood before and after passage through the digestive tract of *Teredo navalis* has shown a loss of about 80 per cent of the cellulose originally present. Evidence has been found that this is due to digestion by a cellulose-splitting enzyme. In order to determine whether the boring mollusks are able to subsist on wood alone, blocks containing specimens of *Bankia setacea* of known size were kept thirty days in aquaria containing sea-water filtered every day through a bacterial filter. They continued in apparent health, and bored more rapidly than control specimens which were given a plankton diet, indicating that a greater amount of wood is required for the nutrition of the organisms when plankton is not available as food.

MISCELLANEOUS

(To be read at New Haven.)

62. *Rate of growth and age at sexual maturity of certain sessile organisms.**

B. H. GRAVE, Wabash College. (10 min.)

Data are given on the rate of development from egg or larva to sexual maturity of *Obelia*, *Bugula*, *Teredo*, *Hydroides*, *Balanus*, *Botryllus*, and *Molgula*, at Woods Hole, Massachusetts.

Obelia, *Teredo*, *Bugula*, *Botryllus*, and probably also *Molgula* become sexually mature during their first season. (A specimen of *Molgula* six weeks old shows well-developed gonads. *Hydroides* and *Balanus* become sexually mature in one year. *Hydroides* also spawns a few eggs after two months old, but its principal reproductive activity begins at one year and continues at least two years.

Wooden structures placed in the water on July 16th contained sexually mature *Teredos* on August 28th. Their burrows at the latter date measured from 1½ to

* This paper was read at the Washington meeting in December, 1924, but the work has been extended during the summer of 1925. Although the data are not yet as complete as might be desired, it is thought best to publish because the missing data must be obtained during the academic year in April, May, and October. The writer has made trips to Woods Hole during these months, but has not been able to obtain wholly satisfactory and complete data.

2 inches in length. *Teredo* larvae which attached themselves about August 20, 1923, were sexually mature late in June, 1924. This was true also of *Hydroides*, although neither had reached any considerable size. *Balanus* was sexually mature in one year and had reached average size. These barnacles developed large gonads late in the summer when two to three months old. The ovaries contained large yolky eggs. Although no spawning was observed during the first summer, it is likely that they spawned in September and October. It was shown that their great period of reproduction was after one year old.

Balanus, *Hydroids*, and *Teredo* spawn most abundantly during their second season, i.e., after one year of age, while *Obelia*, *Bugula*, and *Botryllus* spawn principally before two months old. The number of generations per summer is several for *Obelia*, *Botryllus*, and *Bugula*. Others spawn more than once per season as in the case of *Teredo*.

The rate of development of all these animals is surprisingly rapid when the minute size of their swimming larvae is considered. Piles of piers and hulls of ships that lie at anchor become foul in a few weeks from the growths of sessile organisms.

The rate of growth in these species is shown in the form of an exhibit of preserved specimens and by charts or tables.

63. *The natural history of Bugula flabellata and Bugula turrita.* B. H. GRAVE, Wabash College. (5 min.)

A comparative study of *Bugula flabellata* and *Bugula turrita*.

An account is given of the breeding season, the structure and behavior of the larva; the mode of attachment; metamorphosis; rate of growth of the colony, including drawings, and age at sexual maturity.

The study includes the complete life-history and something on ecology or conditions under which these polyzoa thrive.

- 64.² *Further studies on the life-history of Craspedacusta ryderi, a fresh-water medusa.* FERNANDUS PAYNE, Indiana University. (10 min.)

In 1924 I published an account of the discovery of this medusa in Boss Lake, near Elkhart, Indiana. All the medusae were females. This was the first time the female had been seen. Hargitt reported males only in the aquarium at Washington and Garman reported the same for those found in Benson Creek, Kentucky. The hydroid was also found in Boss Lake, and its history was followed throughout the year. In early summer it reproduces by means of planula-like buds which grow into other hydroids. In the later summer it produces a second type of bud which grows into the medusa. During the winter it contracts into a ball-like mass. As there were no male medusae, the sexual phase remained undiscovered.

During the past summer the hydroid was found in Benson Creek, Kentucky. They were attached to the stones on the bottom of the creek. Some of the hydroids were transplanted to Boss Lake. In September, Dr. W. R. Allen, of the University of Kentucky, reported medusae in the Kentucky River. September 12th, Doctor Allen and I went to the river and found medusae in abundance. A study of these revealed both sexes, and I have followed the development of the egg into the hydroid. This gives the complete life-history of this interesting form.

65.³ *The earlier larval instars of the Odonata.* PHILIP P. CALVERT, University of Pennsylvania. (Lantern; 15 min.)

Our knowledge of the larval stages of the Odonata is chiefly of the last instar. For many purposes identification of the younger larvae is often desirable. Such identification may be accomplished by following individuals through successive moltings and, by a comparison of the consecutive exuviae, tracing the changes which are undergone. The characteristic mask, or labium, which is of great importance in the life of odonate larvae, furnishes also some of the most important taxonomic differentials. Rearings of *Pantala flavescens* by Miss Lamb, of this university, of *Anax amazili* and *Tramea carolina* by the speaker show that of details of this organ possessing specific value for the last instar some are present even in very early instars, while others are progressively developed from an early to the last instar.

For a long time to come we shall probably know the ontogenetic connection of the later rather than of the earlier instars. In such cases terms denoting these stages, counting backward from the last instar, are necessary. For the sake of brevity, the following are proposed, as nouns and adjectives, which may be applied to any group of organisms: ult (for last or ultimate), penult (for penultimate), tertult (antepenultimate), quartult (preantepenultimate), quintult, sextult, septimult, octavult, nonult, decimult (tenth from the end), and so on. These terms may be abbreviated by writing them 5ult, 6ult, etc.

66. *Variation in the number of fin-rays in three species of Fundulus.* R. P. BIGLOW. (Chart; 5 min.)

While investigating the food habits of very young fishes, it was desired to determine the species of young specimens of *Fundulus* captured in Woods Hole Harbor. Other characters failing, counts were made of the fin-rays. These were found to differ so much from the published descriptions of the three species reported from the Woods Hole region that it became necessary to examine the adult forms.

The results obtained by so doing are in part as follows: *F. heteroclitus*, dorsal rays 11-14, mean 12.1; anal rays 10-11, mean 10.7. *F. majalis*, dorsal rays 14-16, mean 14.6; anal rays 11-12, mean 11.1; *F. diaphanus*, dorsal rays 13-16, mean 14.3; anal rays 11-13, mean 12.1.

Thus *F. majalis* and *F. diaphanus* are very like in the structure of the dorsal fin and differ from *F. heteroclitus*; whereas, with respect to the anal fin, *F. diaphanus* differs more from the other two than they do from each other. The numbers of individuals of the three species examined are 77, 32, and 27, respectively.

67. *A simplified method for the cultivation of living tissue in vitro.* GEORGE A. BAITSELL, Yale University. (15 min.)

One of the chief limiting factors in the study of living tissues in vitro has been the difficulties attendant upon the preparation of the cultures, particularly with respect to the culture medium. Two types of culture media have been in general use, namely, blood plasma and various saline solutions. Of these, undoubtedly blood plasma is best, but the difficult technique necessary for securing it greatly

limits its use. The use of saline fluids is limited by the fact that they do not, in general, afford a satisfactory environment, particularly for adult tissues, most of which show no activity with this type of culture medium. It has recently been found (Baitsell and Sherwood, Proc. Soc. Exp. Biol. and Med., Nov., 1925) that the peritoneal exudate of certain animals (e.g., guinea-pig, rat, and frog), affords a superior culture medium.

Fortunately, in the peritoneal cavity of the frog there is an abundant exudate which may be secured from the opened cavity of an anesthetized animal by means of a pipette. A considerable percentage of various adult frog tissues, particularly liver and spleen, when implanted in peritoneal exudate according to the usual tissue-culture technique, will show very marked cellular activity for several weeks at room temperature. The ease with which such cultures can be made, their activity at room temperature, and their long period of survival would seem to make possible a more general use of the tissue-culture method not only in research, but for class work as well.

By title

68.¹ *A cruise on a New Zealand trawler.* C. C. NUTTING, University of Iowa.

Some remarks on the fisheries of New Zealand and a description of the trawler "Gowan," together with the methods and instruments used in the deep-sea trawling industry. The hardships of the fisherman's life will be touched upon, and some of the more important fishes and particularly the outstanding marine invertebrates secured during the cruise will be described.

69. *A collection of fresh-water fishes from Western Panama.* ELLINOR H. BEHRE, Louisiana State University.

This report is a description of a collection of fresh-water fishes made in the summer of 1921 and the winter of 1923 in western Panama between 81°45' and 83°51'W. The river valleys of the Chiriqui Lagoon, Almirante Bay, and Talamanca, on the Caribbean side, were worked intensively, and a sample collection of a typical Pacific-slope river valley, that of Rio Chiriqui del Tire and its tributaries, was made. Forty-nine species, representing thirty-four genera, referable to fourteen families, are described. Among them are one new genus and one new species.

70. *A rapid iron-hematoxylin method.* ELBERT C. COLE, Williams College.

Tissues fixed in Bouin's picro-formol-acetic solution were prepared by the usual paraffin method, and sections not over 15 μ in thickness affixed to the slide with Mayer's albumen fixative. When dry, the slide was passed through xylol and down the alcohols to the 25 per cent grade. It was then flooded with a few drops of the following mordant: ferric chloride, 5.4 grams; potash alum, 12.9 grams; distilled water, 200 cc.

An unripened stock solution was kept on hand; hematoxylin crystals, 5 grams; 95 per cent alcohol, 100 cc. For use, five drops of stock solution were added to 5 cc. distilled water, and immediately before use a drop of ammonia was added. After mordanting for five minutes, one rinsed the slide for thirty seconds in tap-

water and applied a few drops of the ready stain. After two minutes, the excess stain was drained off and the slide exposed to the air for two minutes more. Tissues were differentiated in 1/10 per cent HCl under the microscope. Ammoniated water was used to 'set' the stain at the appropriate time. Tissues were counterstained in erythrosin in 70 per cent alcohol, dehydrated and cleared as usual, and mounted in balsam. Care was taken that the alcohol, xylol, and balsam were not acid. Successful results were secured with a considerable variety of vertebrate and invertebrate tissues. The staining is sharp and intense and the entire procedure is short.

GENERAL AND COMPARATIVE PHYSIOLOGY

(To be read at New Haven.)

71. *Blood calcium (parathyroid) changes and the reproductive cycle in pigeons: a contribution to the sex problem.* OSCAR RIDDLE AND WARREN H. REINHART, Station for Experimental Evolution. (Lantern; 15 min.)

The interpretation of earlier observed effects of continuous or rapid egg production on sex and sex ratios in pigeons may be assisted by an examination of the metabolic changes in the parent soma which possibly accompany each ovulation cycle. Two such changes were earlier identified in pigeons: An increase in the concentration of the blood-sugar—probably involving the suprarenal medulla; and a marked hypertrophy of the adrenal cortex—an organ of much interest in sex studies and probably concerned in variations of thyroid activity.

The present study shows that at each ovulation cycle the calcium of the blood plasma is regularly raised to double its normal value. This signifies a greatly increased output of the parathyroid hormone. Both sexes of ring doves and of common pigeons were examined in thirteen stages of the reproductive cycle (resting period, midovulation, incubation, etc.). Autopsies made immediately after drawing blood for calcium determination permit the separation of diseased from healthy birds. Curves constructed from the data (191 healthy birds, with many duplicate determinations) show average values of 8.9 mgm. and 9.5 mgm. calcium per 100 cc. blood in the 'resting period' of female ring doves and common pigeons, respectively. At ovulation these values were increased to 19.9 and 20.9 mgm. In males the plasma calcium is unchanged or but slightly changed. Crowded reproduction in female pigeons therefore involves a nearly continuous and very profound modification of this animal's normal calcium metabolism.

72. *The spawning of Teredo navalis, L.* T. C. NELSON, Rutgers University. (Lantern; 5 min.)

Teredo navalis produces in New Jersey inland coastal waters two broods of larvae a year. The first appears in Barnegat Bay in late May and early June with water temperatures from 15° to 18°C. approximately two weeks before onset of oyster spawning. *Teredo* larvae of setting age are abundant during the last three weeks of June. The second brood of larvae, produced by individuals which set in June, appears during the first or second week in August with water temperatures between 23° and 25°C. The appearance of the first brood is cor-

related with the attainment of the water temperatures indicated; the spawning of the second brood is determined by the rate of growth and development to sexual maturity of the first brood, in which temperature in New Jersey waters is not a limiting factor.

Wood put out June 11, 1925, was heavily riddled by August. Five minutes after placing this in aquarium, three teredos shed their larvae. These issued in a stream 0.2 mm. in diameter from the excurrent siphon. The stream extended for nearly 3 cm. from the siphon, which was played slowly back and forth like a hose. Spawning continued for approximately two minutes, followed by a second and a third spawning interrupted by intervals of several minutes. The majority of the larvae fell at once to the bottom, rising again quickly and swimming about the aquarium. Measurements of these larvae show a modal length of 74 μ , height 57 μ , hinge line 46 μ .

73. *On the antagonism between thyroid and ovary in relation to the formation of plumage melanins in the domestic fowl.* HARRY BEAL TORREY AND BENJAMIN HORNING, University of Oregon. (Lantern; 15 min.)

The addition of thyroid substance (1:5000 b.w.) to the ration of Brown Leghorn fowls is followed by an increase in the plumage melanins. The sexes differ, however, in their response. Both normal males and capons, on the assumption of adult plumage, become increasingly darker. Normal females similarly treated respond like control females. But one female whose ovaries had been completely removed two weeks after hatching darkened conspicuously. This was the only thyroid-fed poulard under observations.

Although poulards may assume the full male plumage, along with male comb and wattles, this transformation in the present case was at all perfect in connection with the fleshy structures only. The hackles of all the feathers most like those of the male were deeply pigmented and without pattern. So, also, were typical female feathers from back and saddle.

When hackles, saddles, and back feathers were removed from small patches on five two-year-old hens, that were then placed on a thyroid diet, the replacing feathers were somewhat darker than those removed. They were distinctly lighter, however, than corresponding feathers from the thyroid-fed poulard, and their pattern was still evident.

These facts suggest a certain antagonism between ovary and thyroid in connection with pigment formation that has no counterpart in the male.

74. *Factors causing or associated with cold hardiness in insects.* NELLIE M. PAYNE, University of Pennsylvania. (Introduced by J. H. Bodine.) (15 min.)

A. Two factors of heat energy involved in insect cold hardiness: Two factors of heat energy involved in insect cold hardiness are, 1) the intensity factor and, 2) the quantity factor. Insects are able to withstand either large amounts of cold of low or great intensity or extremely small amounts of the quantity factor. Aquatic insects, for example, can withstand long periods of cold of low intensity, but are killed when their protoplasm freezes. Certain other insects, on the other hand, such as those infesting stored products, can withstand intensity of cold, but are unable to survive dormancy. Insects normally exposed to extremes of

low temperature first become hardy to long periods of cold temperatures and finally to intense low temperature. Cold hardness or resistance to cold consists in developing resistance to both the intensity and quantity factors.

B. Osmotic pressure changes associated with development of cold hardness: Osmotic pressure of body fluids of insects calculated from freezing-point depressions shows marked changes during the process of development of cold hardness or cold resistance. Such changes are periodic in insects normally hibernating. Changes in osmotic pressure can be experimentally produced by exposure of insects to varying temperatures and humidities.

75.² *Chemical reactions of Nereis virens.* MANTON COPELAND, Bowdoin College. (15 min.)

Nereis, in a glass tube open at both ends, frequently carries on undulatory movements of the body, drawing a stream of water through the tube. When an extract of clam is added to the water, the worm responds by moving to the end of the tube, where it will seize and swallow a piece of clam. On the removal of a part of the worm's equipment of head appendages, the reaction is often less definite and more slow, or it fails to be completed. When all the peristomial cirri, tentacles and palps are excised, the worm still gives evidence of sensing the food, although many times it does not go to the end of the tube, and the food-seizing reaction, which in part is probably the result of tactile stimulation, practically ceases. On regeneration of the appendages, the normal response returns. When the posterior end of the worm is stimulated, it frequently turns in the tube and moves to the end, the receptors of the caudal cirri playing a part in the reaction. If the stimulating material comes in contact with the body between the anterior and posterior ends by being forced through a hole in the tube, a reaction is initiated which usually results in the head's being thrust into the hole. *Nereis* evidently is sensitive to food juices over the length of its body, but depends largely on the receptors of specialized terminal appendages in finding food of the type used in the experiments.

76. *The prevention and cure of tetany by oral administration of strontium.* W. W. SWINGLE AND WM. WENNER, Yale University. (Lantern; 8 min.)

Destruction of the parathyroid glands of dogs causes death from tetany within a few days. It has been known for some time that calcium administration prevents, relieves, and even cures tetany.

In experiments performed upon twenty-seven dogs we demonstrated that strontium when given orally acts like calcium, in so far as tetany is concerned, although it is somewhat less effective. The strontium acts in two ways: 1) by decreasing the permeability of the gut to calcium excretion so that the normal level of this salt is maintained in the blood and tissues and, 2) by a sedative effect upon the nervous system whereby the excitability of the motor nerves is greatly diminished.

Strontium cannot substitute for calcium, but it does prevent the latter from escaping from the organism. The lowering of the calcium of blood and tissues following parathyroid removal is due to rapid elimination of this salt by way of the alimentary canal. By a variety of means, we have been able to show that any agent which decreases the permeability of the gut to calcium will prevent, relieve, or cure tetany. We have found several such agents.

Thyroparathyroidectomized dogs kept free from tetany by strontium or calcium for forty days following operation readjust themselves to loss of the parathyroids and permanently recover. The mechanism of adjustment is not clear. The animals can be thrown into violent tetany at will up until the thirty-fifth day. After this time, recovery is permanent.

77. *The effect of bleeding upon the serum calcium of parathyroidectomized dogs.* W. W. SWINGLE AND WM. WENNER, Yale University, and the Biological Laboratory, Cold Spring Harbor. (Lantern; 7 min.)

If parathyroidectomized dogs exhibiting violent tetany are bled, the symptoms promptly disappear. Dogs presenting alarming symptoms return to normal temporarily following withdrawal of 100 cc. of blood.

The striking abatement of tetany which follows bleeding has always been interpreted as the effect of the removal of a circulating poison produced in excessive quantities after destruction of the parathyroids. An adequate explanation to account for the phenomenon has never been advanced. Recently we discovered the reason for the cessation of symptoms by measuring the level of the serum calcium before and after bleeding.

The calcium level of the serum of normal dogs is about 10.5 mg. per 100 cc. Following the onset of tetany, the calcium falls to about 6 mg. There is considerable variation, but the serum calcium is always below 7 mg. before manifest tetany appears. After bleeding, the tetany disappears, and if the calcium level is then measured it will be found to be about 8.5 mg. Thus bleeding induces a marked rise in the level of the serum calcium. We have repeatedly obtained rises of 29 per cent within a few hours. A rise in the calcium level above 7 mg. per 100 cc. causes the tetany symptoms to disappear.

The remission of tetany symptoms which follows bleeding is not due to diminution in concentration of a circulating toxin, but is due solely to the increase in utilizable calcium which results from such procedure.

78. *The locomotion of the sand-dollar Echinarachnius.* G. H. PARKER, Harvard University. (15 min.)

When a sand-dollar is placed upon damp sand oral side down, it revolves slightly on its own axis till one edge of its shell is below the sand, whereupon it buries itself. The same individual may revolve clockwise or counter-clockwise. In moving over the surface of the sand and in digging into the sand the edge of the shell opposite the anus is moved forward. Sand-dollars rest naturally under the sand with the oral face down. When they are buried in sand oral face up, they quickly reverse. Their sphaeridia are not essential for their geotropic responses.

79. *Metabolic rate and bunching in catfish.* M. W. EDDY, Dickinson College. (Introduced by W. C. Allee.) (15 min.)

The black catfish *Amieurus melas* normally aggregate in the young stages and the adult stonehead catfish *Schilbeodes insignis* may aggregate when resting.

The aggregation may be controlled by increasing or decreasing the metabolic rate of the individuals by placing fish in water containing various stimulants or

depressants, also by varying the temperature of the water. These fall under four classes.

Aggregations may be made more dense by caffeine 1 part to 10,000 of water, resulting in the aggregation occupying about half as much area as in the control, then for a short period returning to nearly normal, and later coming together in a very close bunch, and the individuals have a tetanized condition of the fins and tails.

More dense aggregations at first and later scattering of the individuals may be secured by using caffeine 1 to 6000, 2 per cent alcohol, and strychnine sulphate 1 to 100,000.

Bunching may be broken up entirely by placing the fish in potassium cyanide 1 to 400,000 or chloretone 1 to 10,000.

Aggregations may be broken up by rapidly decreasing the temperature to 10°C. or lower or by rapidly increasing the temperature to 33°C. or higher. At the beginning of rise of temperature bunching is closer.

Antagonistic action of chloretone and caffeine can be demonstrated on the same bunch by placing fish in chloretone until they break up bunching and then in caffeine until they become closely bunched. Sight also plays a rôle in bunching, since individuals with eyes removed do not aggregate.

80. *Observations of the food reactions of Actinophrys sol.* J. B. LOOPER, University of Virginia. (Introduced by Wm. A. Kepner.) (10 min.)

Observations on the reactions of the following objects were recorded: Inanimate objects, motionless animate objects, and moving animate objects, including rotifers. The conclusions are recorded as given below:

1. Certain inanimate objects are ingested by *Actinophrys sol*, while others are not.
2. *Actinophrys sol* is essentially omnivorous.
3. Motionless animate objects are accepted, but not in appreciably greater numbers than inanimate objects.
4. Many free-swimming ciliates and flagellates are eaten readily, but certain ciliates are rejected.
5. A degree of selection or discrimination was exercised between different food objects in every class of materials used.
6. Large objects are sometimes taken in by groups of *Actinophrys sol* formed specifically for the purpose of taking in such objects.
7. Moving objects are paralyzed by the tips of the rays and are ingested by special food-getting pseudopods.
8. As a rule, inanimate objects and motionless animate objects are closely embraced by the special food-getting pseudopod; objects which struggle, while being ingested, are subtly embraced.

81. *Reactions of Hydra to inanition.* WM. A. KEPNER AND P. N. JESTER, University of Virginia. (5 min.)

Hydra, as a diploblastic animal, can have no circulatory medium. Perhaps for a similar reason it can have no storage tissue, such as fat. Green hydras seem able to fall back upon the surplus foods of its zoochlorellae, for, contrary to some observers, it has been our experience that *Hydra viridis* is much less influenced by inanition than other species.

In all species, if the inanition be prolonged and the individuals be kept free from parasites and concentrated toxins, each specimen, not getting food, will begin to feed upon its tentacles. First, the ends of the tentacles are bitten off. If, now, food is yet withheld from the hydra, it will feed upon its tentacles until but the merest stumps are left.

The ingested tentacles will be digested. Even the nematocysts (both types) will be taken into food vacuoles within the epitheliomuscular cells and be completely digested and absorbed.

After the hydra has thus fed upon and appropriated its tentacles except for mere stumps that stand about the peristome, these bases of the amputated tentacles will regenerate, and the hydra, now reduced in size, will possess a new group of tentacles.

In feeding upon the tentacles that have been ingested, the endoderm of the stumps of tentacles appropriate relatively more of the ingested tentacle material than is appropriated by the endoderm of the body proper. This appears to be correlated with the fact that regeneration is to take place in the tentacular stumps.

82. *Specificity of integument in the spotted newt, Triturus viridescens.* H. H. COLLINS, University of Pittsburgh, and E. F. ADOLPH, University of Rochester. (Lantern; 10 min.)

There is a marked contrast in the coloration of the dorsal and ventral surfaces of the vermilion spotted newt. The dorsum is greenish black with a variable number of brilliant red spots, linearly arranged on each side of the dorsal median line. The ground-color is mainly due to the numerous isolated melanophores. In addition to these, there are numerous aggregates of melanophores forming black spots. The ventrum is lemon yellow, with black spots, variable in number and size. There are no scattered melanophores. The dorsal and ventral regions are sharply separated by a 'lateral border.'

Specificity of integument was studied both in regeneration and transplantation experiments. Removal of integument is followed by restoration of dermis and epidermis. Melanophores from the surrounding skin move into the wound area, and after several months they may aggregate to form spots. The normal pattern is finally attained, though the exact arrangement of spots is not duplicated.

Grafts of the dorsal skin on the ventrum or of ventral skin on the dorsum do not maintain complete specificity indefinitely, but are gradually transformed so as to approach the condition of the surrounding skin.

The behavior of the melanophores during morphogenesis differs for specific areas of integument. Their movement and aggregation appear to be markedly coordinated.

By title

83.¹ *Autonomy and regeneration in the house centipede, Scutigera forceps.* JOHN A. CAMERON, University of Nebraska. (Introduced by D. D. Whitney.)

The house centipede, *Scutigera forceps*, has long been known to possess the power of dropping and replacing its legs. The legs separate from the body close to the body wall at a special joint or plate which prevents excessive loss of body

fluid after the removal. Legs are replaced by the growth of full-sized legs underneath the shell and are liberated as functioning appendages at the next molting. Antennae are not dropped or replaced during adult life. The time of molting is not affected by the number of legs removed nor by the time of removal with relation to the date of molting, excepting individuals having all the legs removed which shed and regenerate them in one-half the normal time. All legs removed previous to the seventh day before molting are regenerated full size at the molting, but no sign appears of the legs removed less than seven days before molting. The following periods of molting have been determined: 20°C., 60 days; 25°C., 45 days; 30°C., 30 days; 35°C., 30 days; 40°C., 30 days; 45°C., 26 days. Higher and lower ranges of temperature are being worked out at present.

Starvation and variation in foods do not affect the time and character of regeneration. The animals become senescent and lose their power of regeneration after the ninth or tenth molt in adult life. Just before death, the legs often become pale and limp and drop off at the slightest touch.

84. *The effect of breathing cigarette smoke upon young rabbits.* W. J. BAUMGARTNER, University of Kansas.

Forty-six rabbits in five series were tested for the effect of cigarette smoke upon their growth and behavior. Litters were divided at weaning time into two groups, always separating them as nearly equally as possible into pairs. One group of each series was subjected to cigarette smoke for three half-hour periods each day. Smoking was continued in the various groups from eleven to twenty-three weeks. Otherwise the groups were kept under identical conditions.

The smoked rabbits always showed excessive salivation, stupor, and sometimes paroxysms during and immediately after the administration of the smoke.

Weekly weighings showed that the smoked rabbits failed to gain in weight as rapidly as the normals. The greatest retardation seemed to be around the fourth or fifth week. A few rabbits kept for some weeks after the smoking was discontinued did not regain the loss in weight.

Smoked rabbits neglected markedly to care for their fur and presented an unkempt, dirty appearance. This showed very clearly in the albinos.

The smoked individuals were lethargic and inactive, playing, digging, or fighting but little as compared with the normals. Sexual activity was evidenced from two to three weeks later.

The retarded growth and the lessened activity accords with the carefully measured stunted development and reduced muscular and mental powers found by certain investigators in human smokers as compared with non-smokers.

85. *The nerve plexus of the earthworm, Lumbricus terrestris.* WALTER N. HESS, Depauw University.

Histological preparations by the Boule silver nitrate, intra-vitam methylene blue, and gold-chloride methods show the presence of a network of nerve fibers in the tissue of the earthworm, with protoplasmic thickenings at many of the nodes which appear to be nerve-cell bodies. Fibers pass out from these nodes in many directions, giving the appearance of what is commonly considered a nerve net. This network was especially studied in the circular and longitudinal muscles.

Nerve fibers pass directly from the sensory cells, by way of the subepidermal nerve plexus, into this network, and also from the central nervous system by way of spinal nerves.

Isolated segments of the earthworm with the central nervous system removed responded to the same general experiments with mechanical stimuli as Parker ('18) reported for *Metridium*. Similar experiments on portions of earthworms with the central nervous system removed showed that this network, together with the subepidermal nerve plexus, is capable of transmitting impulses over as many as six somites. With heat as a source of stimulation, impulses were transmitted over as many as fifteen somites.

In these experiments the worms were slit along the midventral line, and the viscera, including the central nervous system, were removed. These portions of the body wall were then slit at intervals, both lengthwise and crosswise, and pinned out tightly in order to prevent as far as possible direct muscle conduction of stimuli and to keep the muscles from stimulating, as a result of their contraction, the muscles of neighboring segments.

86. *The effect of bunching on oxygen consumption in land isopods.* W. C. ALLEE, The University of Chicago.

The oxygen consumption of recently collected *Tracheoniscus* (*Porcellio*) *rathkei* and *Armadillium vulgare* was tested quantitatively, using a slight modification of Krajník's respirometer. Such land isopods, if recently bunched, consume less oxygen per unit weight than do recently isolated individuals. Four sets of experiments show the following ratios: 1:1.211, 1:1.344, 1:1.399, 1:1.368.

Bunching reduces the tendency to move about, but this is not the sole cause of the differences here observed, since readings were discarded when noticeable movement occurred; however, the observed differences may well be due to changes in muscular action or tension which did not result in marked movement.

Isopods left without food for twenty-four hours consume less oxygen than at the start, whether bunched or isolated, but there is a much greater decrease in respiration with isolated individuals when all other known conditions are similar. Observed ratios for isolated animals are: 1:0.299 and 1:0.35; for bunches: 1:1.454 and 1:1.411. The decrease is so much less with the bunches that after standing twenty-four hours they are respiring about 50 per cent faster than similar isolated animals which when first tested were using about one-third more oxygen. The differences in all cases are twelve or more times the combined probable errors of the means.

These results support work previously reported to the Society and indicate that the habit of forming close aggregations which these isopods exhibit in nature under adverse conditions helps maintain better physiological conditions than would obtain with isolated individuals.

87.¹ *The disintegration of Planaria maculata in KCN.* J. W. WILSON, Brown University.

The disintegration of *P. maculata* in M/1000 KCN in pond water is due to the cytolytic effect of the hypotonic medium which invades the body locally at the eosinophilic slime-producing region along the margin. This region is the most susceptible part of the body surface, and its rupture permits the invasion.

The cytolysis may be prevented by substituting for pond water M/1000 KCN in a Ringer's fluid approximately isotonic with the body fluid of the flatworm. In this solution the flatworm remains intact, alive, and irritable from two to three times as long as would be required for complete cytolytic disintegration in the pond water, and when the worm eventually dies and disintegrates in the isotonic fluid, the disintegration is not a cytolysis, but a dissociation of the cells, which themselves are, for the most part, intact. The substitution of Ringer's fluid for pond water has no appreciable effect on the rate of oxygen consumption of the flatworms. It is, therefore, concluded that the disintegration of *P. maculata* in M/1000 KCN in pond water is not initiated by the specific effect of the KCN on the oxidative metabolism of the worm as a whole, but is produced by the cytolytic action of the hypotonic medium before the KCN has had time to produce its specific effect.

88.¹ *Some conditions affecting the hibernation of the thirteen-lined ground-squirrel, Citellus tridecemlineatus.* GEORGE EDWIN JOHNSON, Kansas State Agricultural College.

Experiments have been conducted to determine the comparative effect upon hibernation of light and darkness and of feeding and starving the pallidus variety of *Citellus tridecemlineatus*. The animals were placed in a refrigeration room for periods varying from one to three weeks at temperatures usually ranging from about 2°C. to about 13°C. Nineteen of these experiments, covering a period of nearly ten months, have been completed. The animals partially starved went into hibernation more readily than did those which were fed all they would eat. The ground-squirrels placed in cages from which light was excluded went into hibernation to practically the same extent as did animals in the same cold room in cages illuminated by artificial light.

In the experiments mentioned, less hibernation was induced in the cold room in the month of April to July, inclusive, than from January to May, or from August to October, inclusive.

Other experiments have shown that ground-squirrels placed in covered containers of limited space and in which they could get only a small supply of atmospheric oxygen would become torpid more readily than control animals kept in open cages in the same cold room.

89. *The effect of ultraviolet radiation upon the tetany syndrome.* W. W. SWINGLE AND J. G. RHINHOLD, Yale University.

Ultraviolet radiation profoundly influences calcium and phosphorus metabolism, and prolonged exposure of normal animals raises the level of the serum calcium. Parathyroid tetany is probably due to faulty calcium metabolism, and is invariably associated with greatly diminished concentration of this salt in the blood and tissues. Hence it was considered worth while to try the effect of radiation upon parathyroidectomized dogs, animals in which the onset of tetany is sudden, violent, and fatal within a few days.

The animals were radiated one hour a day before operation for periods varying from two to twelve days. Following operation, the dogs were radiated three and four hours a day.

The ultraviolet ray has a marked ameliorative effect upon tetany—violent symptoms disappear, the animal quiets and may return to normal for hours. Repeated serum-calcium determinations failed to show any rise in the level of this salt. Coincident with the appearance of tetany, it falls from around 10.5 mg. per 100 cc. to 6 mg. or below and remains at this low level. The life of tetany animals can be considerably prolonged by radiation. Ten dogs were used and the survival periods in days following operation are: 25, 23, 18, 16, 9, 8, 6, 5, 2, and 2. The last three animals died in convulsions while being handled for bleeding. Dogs surviving ten days pass into a tetanoid condition, characterized by absence of tremors, somnolence, depression, and low blood calcium. Such animals eventually die of exhaustion.

90. *The relation of the mammalian follicular hormone to the development of secondary sexual characters.* W. W. SWINGLE, WM. WENNER, AND M. STEGGERDA, Biological Laboratory, Cold Spring Harbor, and Yale University.

In a recent paper, Allen, Doisy, and collaborators have expressed their belief that the hormone of the mammalian follicular fluid is the principal female sex hormone. The following experiment was designed to test this view.

One Brown Leghorn and six Rhode Island Red male chicks were castrated at an early age, before any signs of the typical male plumage had appeared. The birds were injected intraperitoneally once each week with 3 cc. of clear follicular fluid aspirated from the ripe follicles of freshly killed hogs. Two birds died after the sixth injection (18 cc. given), or about six weeks after castration. Both showed a few cock feathers. Three other birds died after receiving 40 cc. of the follicular fluid, or about eleven weeks following the first injection. At the time of death they were typical young capons. The plumage was male. The remaining two birds are still alive. They have each received 55 cc. of follicular fluid and are cock-feathered with the head furnishing of capons.

One of the writers has demonstrated that the ovaries of mammals when injected into castrated cockerels causes the assumption of hen plumage. It seems probable, therefore, that the follicular hormone is a reproductive hormone only, and its sphere of influence is confined to the female genital tract. Our experiment indicates that it is probably not the principal female sex hormone, which has to do primarily with sex differentiation and development of secondary sexual characters.

91. *The effect of thyroidectomy and glucose administration on the life-span of adrenalectomized cats.* R. L. ZWEMER, Yale University. (Introduced by W. W. Swingle.)

In work previously reported, it was shown that the cortex is the part of the adrenal essential for life and that transplants of this portion of the gland considerably prolong the survival of adrenalectomized animals. The following results were obtained in an attempt to experimentally control the length of the survival period.

Controls: Twelve cats deprived of both adrenals (in two stages, seven days apart) survived the second operation by less than three days.

Thyroid absence: Ten animals, subjected to the same conditions as the controls, but with the thyroids also removed at the first operation, survived double adrenalectomy by an average of nine days; one animal living twenty-two days.

Thyroid excess: Six animals were thyro-adrenalectomized, and in addition were each fed 4 grains of desiccated thyroid per day during the period between the first and second operations. These survived the second operation only twelve to twenty-four hours. Four normal cats were fed equal amounts of thyroid for the same period with no ill effects.

Glucose administration: The adrenals were removed in two stages, from seven animals. Following the second operation, each animal received 100 cc. of 5 per cent glucose solution three times a day. The animals lived six to ten days after the final operation, the average life-span in this series being three times as long as the controls.

The survival period of animals experimentally deprived of their adrenals can be considerably prolonged by thyroid removal or glucose administration and shortened by thyroid feeding.

92.¹ *The ovarian follicular hormone: variations in amount in pig, cow, and human ovaries during the oestrous and menstrual cycles.* EDGAR ALLEN, University of Missouri School of Medicine.

Comparison of the oestrous cycle of lower mammals with the menstrual cycle of Primates reveals two striking differences: The oestrous cycle is characterized by a restricted period of sexual desire and an absence of uterine hemorrhage, while the menstrual cycle has its typical hemorrhage, but no restricted mating period.

Searching for a possible cause in the ovary, quantitative analyses have been made of the variation in amount of hormone in ovarian tissues during different periods of the cycles. The unit of measurement used was the least amount of lipid extract of ovary required to induce full oestrous growth in the vaginal epithelium of the spayed rat in three days. This growth amounts to a complete replacement of the stratified epithelial wall.

Accurately timed ovaries of pigs (collected by Doctor McKenzie, University of Missouri) and cows (collected by Doctors Murphey and McNutt, Iowa State University) have returned high yields during oestrus when the follicles are large and negative results after oestrus when corpora lutea are developing in the ruptured follicles. Extracts of human ovarian tissues (removed at operation by Doctor Pratt, Henry Ford Hospital) show a high hormone content in the fluid from large follicles, and also, in contrast to results from pigs and cows, the presence of considerable amounts in corpora lutea.

Since earlier work has clearly demonstrated the striking action of this hormone upon the genital tract and upon oestrous instincts, these findings seem significant in a consideration of the causal factors underlying the oestrous and menstrual cycles.

93. *Some observations on the spiral movements in mice.* INEZ DUNKELBERGER, University of Kansas. (Introduced by A. A. Schaeffer.)

A series of observations was made on twenty-seven young of *Peromyscus maniculatus bairdi*, the common white-footed deer mouse of the plains, to determine whether or not these animals, deprived of their guiding sense organs, swim in any definite course. The mice were made to swim in a large tank containing water to a depth of 6 to 8 inches. Experiments were made both before and

after the young had the eyes open. The older specimens were blinded by pasting adhesive tape over the eyes. It was found, 1) that such animals swim without exception in clock-spring spirals; 2) that the size of the circles is usually from 3 to 10 inches in diameter; 3) that certain individuals swim predominantly in right- or left-hand spirals.

94. *Nutrition of the ovum of Hydra.* WM. A. KEPNER AND J. B. LOOPER, University of Virginia.

The nutrition of the ovum of *Hydra* presents two phases. In the first phase the oogonium is nourished by the material or substance of interstitial cells so that it grows into a large amoeboid primary oocyte that lacks any trace of deutoplasm. The object of this first phase appears to be the supplying of the oogonium with material whereby it may grow and bring itself into extensive surface relation with the endoderm.

In the second phase of nutrition the amoeboid primary oocyte draws food material from the endoderm. Out of this food material it elaborates deutoplasm. This deutoplasm cannot be modified nuclei that represent the lineal descendants of nuclei of appropriate interstitial cells, as has been held previously. The second phase of nutrition is closed when the primary oocyte abandons its relation to the endoderm and, by withdrawing its many pseudopods, becomes spherical. The object of the second phase is to supply deutoplasm for the ensuing embryological life.

95. *Further experiments upon the regulation of body volume in earthworms.* EDWARD F. ADOLPH, University of Rochester.

The influences of handling, of changes in temperature, and of various solutions upon the average body weight have been studied in extension of data recently reported (Jour. Exp. Zool., Nov., 1925). Superficial drying upon filter-paper, which was incident to weighing the earthworms, caused a rapid loss of weight (7 per cent) during the first hour of each day. Worms were customarily reduced to basal weight by repeated handling before weights were taken.

The body weight was always maximal at about 17°C. In cold water weight was lost (10 per cent at 3°C.), and likewise in warm water (4 per cent at 28°C.). The changes were initiated immediately and proceeded at rates such that each loss was roughly proportional to the logarithm of the time elapsed.

In all solutions which were tested earthworms initially lost weight; some up to half of the basal weight. The amount of loss was related to the osmolar concentration of the solution; this was true for urea, sucrose, NaCl, and KCl. Both the rate and amount of loss were proportional to the area of the body surface.

The Δ of earthworms was found to be 0.17 osmolar, increasing temporarily during treatment with solutions, but remaining constant over a period of one month.

The total chloride concentration of the body was increased from 0.25M. to 0.029M. in animals which had been immersed in chloride solutions, due to absorption of this substance. The absorbed excessive chloride was retained for at least one month after removal. The chloride concentration also increased temporarily during treatment with solutions or after changes of temperature.

During the period of a month 15 to 30 per cent of the body weight was lost; it is apparent that the total concentration of the body's fluid was carefully regulated, and not the body's total volume.

GENETICS

(To be read at New Haven.)

96. *The fertility behavior of the black rat, Mus rattus, a wild species under domestication.* HORACE W. FELDMAN, Bussey Institution. (Introduced by W. E. Castle.)

The study involved 905 animals, consisting of the descendants in four generations of wild *Mus rattus*, wild *M. alexandrinus*, and nine specimens of a cage-bred strain of the former. Hybrids between *Mus rattus* and *M. alexandrinus* were easily obtained, but their fertility behavior indicates that the two species are not completely compatible. Rats of these two species with their descendants after hybridization formed a homogeneous population regarding anatomical characters. Individual variability of fertility behavior was marked. Over 50 per cent of the animals were excessively nervous and reared no young. Their frequency decreased in successive generations of cage-reared animals. Approximately one-quarter of the males were inclined to become excessively fat, and in that condition were sterile. The most frequent cause of sterility in the remainder of the population was a condition which may be termed 'psychical incompatibility.' The females, in varying degrees, refused to mate with certain of the males with which they were caged. Although the most fertile rats were bred from in each generation, the percentage of fertility decreased in successive generations. Some evidence of a sterility factor which behaved as a mendelian recessive was obtained. The females of this stock were productive between the ages of seven and twenty-six months. Age fluctuations of litter size and frequency did not occur. The average female produced 2.4 litters. Litters contained from one to twelve individuals; the average size was 5.74 rats. Size of litter decreased in successive generations of cage-bred animals.

97. *On a mendelizing structural defect of the retina producing blindness in the house mouse.* CLYDE E. KEELER, Bussey Institution. (Introduced by W. E. Castle.)

This ophthalmic anomaly, characterized histologically by the complete absence of rod and external molecular layers from the retina, together with a reduction of the external nuclear layer, causes total blindness. It affects both sexes alike, carries no lethal action, breeds as a mendelizing recessive, and is probably not linked with any other known mendelian character. It may be affected by modifying factors. It appears to result from a postnatal inhibition of differentiation in the nervous tissue ordinarily destined to produce the sensory receptor mechanism of the eye.

98. *A case of non-disjunction of an autosome in mammals.* W. H. GATES, Louisiana State University.

In a cross involving a Japanese waltzing and a normal fancy mouse, the latter from a strain in which the waltzing character had never occurred, a waltzing female was obtained in the F_1 . All sibs of this female were normal. Since waltzing is recessive, the appearance of this character in the F_1 presents an abnormal mendelian behavior. The following possibilities are open: a patho-

logical condition, a mutation of the normal gene in its allelomorphie association with the waltzing gene, a new dominant mutation producing waltzing, a deficiency of the gene normal, or non-disjunction in gametogenesis of the two chromosomes carrying normal. The last two would be indistinguishable genetically in the absence of linked factors. All of these possibilities have been tested. The first three are untenable in the light of hereditary behavior, and the weight of evidence so far collected is that it is a case of non-disjunction. These conclusions are based on the following facts: Mated to waltzers, this F_1 produces only waltzers; mated to normal, she produces only normals. Offspring from the first type of mating are low in vitality, slow in maturing, and so far have not been tested inter se. Offspring of the second type are of two genetic types; those that produce waltzers, as would be expected of normal heterozygotes, and those that do not produce waltzers, showing the absence of this gene, which fact is accountable for on the non-disjunction hypothesis. Cytological count of chromosomes has not been made.

99. *Further experiments with x-rayed mice and their descendants.* H. J. BAGG, E. C. MACDOWELL, AND E. M. LORD, Cornell Medical School and Carnegie Institution.

Physical conditions of irradiation as nearly as possible the same as those previously reported (Bagg and Little). Litters born before treatment used as controls; all matings between brothers and sisters. Treated animals were mated alternately with treated and normal mates; offspring inbred as far as F_3 . Numbers of young as follows: both parents treated, F_1 , 76, F_2 858, F_3 533; one parent treated, F_1 264, F_2 1175, F_3 994; same parents before treatment, F_1 275, F_2 1669, F_3 2308. Individuals were found with defects of head, eyes, jaw, or foot in each of the three types of mating (0.35 per cent, 0.24 per cent, 0.20 per cent).

In many cases such defectives died without issue; in the cases that could be tested genetically no evidence of any simple mendelian inheritance was obtained, although the defect might be found in later generations.

Within the limits of the accuracy of the gross examination of the young, these results are unquestionably negative. Obviously, the possibility of modifying the germ plasm by x-radiation is not hereby precluded, for the chances of a germ cell modified in this way to survive the competition of normal gametes and zygotes until maturity of the individual is probably very small indeed. Even though the results are negative, these numbers are considered sufficient for the repetition of the original treatment and to justify the authors in using a considerably higher dosage in the next experiment. In preparation for this, special studies on the sterilizing dosage for males are in progress.

100. *Factors influencing the number of corpora lutea in mice; parity vs. age.* E. C. MACDOWELL AND E. M. LORD, Carnegie Institution.

Graphs are presented, based on 828 counts of the corpora lutea of pregnancy in mice mated before maturity and remated on the day of birth of each litter. The counts have been classified by the age of the female and do not go beyond the ninth month. Within each age class the average number of corpora lutea

for second litters is higher than that for first litters; third litters average higher than second litters; fourth litters average slightly higher than third litters; fifth litters, higher than fourth litters. That is, for a given age class later litters have higher counts, but the differences get smaller after the third litter as the maximum capacity is approached.

From the same parity there is shown no general tendency for the averages to rise with the age of the mother.

These results seem to indicate that the previous reproductive activity of the mouse has more influence upon the number of corpora lutea than its age.

101. *The egg production of a cross between two highly productive races.* H. D. GOODALE, Mount Hope Farm, Williamstown, Massachusetts.

It was desired to learn whether or not the egg production of two highly productive races when crossed would exceed that of either race. Two Rhode Island Red males of the Massachusetts Agricultural College strain were mated to White Leghorn females of the Mount Hope Farm strain. Each strain has an average winter egg yield of about sixty-five eggs. Two hundred F_1 females averaged seventy-five eggs, thus showing an increase which is presumably due to the cross. For the remainder of the year, no increase that can be ascribed to the cross has been noted.

102. *Data on the inheritance of spurs in the female of domestic poultry.* H. D. GOODALE, Mount Hope Farm, Williamstown, Massachusetts.

By selection, a race of poultry was developed in which 50 per cent of the females bore well-developed spurs. Two females of this race were crossed with a Cornish male of a strain in which spurs on the female were never observed. F_1 females had no spurs, but in F_2 one spurred female appeared out of twenty-nine. In addition, one female had a spur on one shank only. Back-crossed to the spurred race gave a larger per cent of spurred females, two females in particular of the spurred race giving 50 per cent spurred daughters when mated to an F_1 male. The reciprocal cross gave non-spurred daughters.

103. *The genetic relations of some shank colors of the domestic fowl.* L. C. DUNN, Storrs Agricultural Experiment Station.

Evidence from crosses between varieties differing in shank color indicates that the inheritance of the colors yellow, white, slate (blue, gray), and green (greenish black, willow, light green) may be explained by reference to two chief factors: *W* determines inhibition of yellow (lipoid pigment) in the epidermis and is present in birds with white, pinkish-white, pearl, blue, slate, and gray shanks. It shows practically complete dominance and is not sex linked. *Y* determines inhibition of melanic pigment in the dermis and is present in white-, pearl-, and yellow-shanked fowls. It is nearly completely dominant and is sex-linked. The genotypes of the shank colors studied are as follows:

$W(w)Y(y)$: white, pinkish white, pearl, light blue (may show flecks of dermal pigment).

$W(w)yy$: slate, blue, dark blue, gray.

$wwY(y)$: yellow (may show flecks of dermal pigment).

$wwyy$: green, greenish black, willow, light green.

Results of breeding tests of the various types are given. A mosaic is described in which the left leg was green (wwy—) and the right leg slate (Wwy—).

104. *Observations on the cellular basis and embryonic development of mendelian characters in the Japanese fish, Aplocheilus latipes.* H. B. GOODRICH, Wesleyan University.

The mendelian color characters of this fish, as previously reported, are due to the presence of certain pigment cells, the melanophores and xanthophores. These are involved in the production of the 'Wild' type, BBYY; the yellow, bbYY; the white, bbyy; the yellow variegated b'b'YY; and the white variegated, b'b'yy.

All types of cells are apparently present in equal numbers in all color varieties. The different color effects are produced by the degree of formation of pigment in these cells. This conclusion is based upon, a) counts of cells in scales of adult fish after treatment with adrenalin which concentrates the pigment and makes cell outlines more clear or after dissolving the yellow pigment which also renders the count more accurate, and, b) counts in young fish after the adrenalin treatment.

The effect of the factor BB (involving the melanophores) may be noted on the second day after fertilization or at a stage of about 11 somites. Mendelian ratios can be detected at this time. Similarly, ratios involving variegation and the yellow character may be detected at time of hatching, or about twelve days.

105. *Temperature as a factor in sex control in Cladocera.* A. M. BANTA AND L. A. BROWN, Carnegie Institution.

Previous reports have dealt with the control of male production in *Moina macrocopa* by crowding the mothers, by treating with chloretone, and by low temperatures. Our usual 'crowded' bottle contains ten mothers and at 20° to 25°C., produces a variable percentage of males, the average being about 43 per cent males. More heavily crowded bottles produce higher male percentages. At the same temperature, less crowded bottles produce fewer males, while single-mother bottles very rarely produce males at all.

As previously learned, crowded or semicrowded bottles at about 15°C. produce many more males than at laboratory temperature (20° to 25°C.). Later extensive experiments with lower temperatures, 12° to 14°C., have shown that male percentages in slightly crowded (two- to five-mother) bottles approach that for ten-mother bottles at laboratory temperatures. Further, at 13°C., single-mother bottles likewise produce approximately as many males as the usual ten-mother bottles at laboratory temperature. Hence low temperature with single-mother bottles is as effective for male production as crowding in ten-mother bottles at laboratory temperatures; and temperature per se is now shown to be a potent and self-sufficient factor in controlling male production in *Moina macrocopa*.

This result renders unessential the difficult search for specific chemical substances involved in the 'balance of excretory products' previously recognized as the most potent factor in control of male production in this species.

106. *Races or subspecies in Reticulitermes*. T. E. SNYDER, U. S. Department of Agriculture.

Races or subspecies recently have been discovered of the termites *Reticulitermes lucifugus* Rossi in Europe and of *R. flavipes* Kollar in the United States.

It may eventually be proved that new species of *Reticulitermes* are being evolved. Certain species are very close morphologically and races or subspecies exist; close species may be merely variations. Here is an excellent opportunity for cooperation between entomologists of Europe and America to establish, 1) the original habitat of *flavipes*, whether from Mexico, the United States, or Europe; 2) whether there is cross-breeding between species and the consequent production of hybrids; 3) whether interbreeding between the different reproductive types within the species—which occurs in nature, but which we have not been able to promote artificially in glass breeding cages—may result in progeny differing from normal.

Detailed investigations by many students are needed. Fundamental principles of great importance and broad application are involved. Possibly evidence may be obtained as to the evolution of species.

107. *Reddish—a frequently 'mutating' character in Drosophila virilis*. M. DEMEREC, Carnegie Institution.

A newly found, sex-linked reddish-body character gave yellow F_1 generation when crossed with already known yellow-body character, indicating that it is an allelomorph of yellow. The F_2 generation, however, gave, in addition to the expected yellow and reddish classes, some wild-type flies, making the previous assumption questionable. Crosses involving several factors located in the yellow region in the X-chromosome showed conclusively that all gray-body flies obtained in the crosses between reddish and yellow had a reddish chromosome in which the wild allelomorph was substituted for the reddish. Crossing over is the usual way by which one factor is substituted in a chromosome for another. In this case, however, crossing over cannot explain this substitution of wild for reddish. The mechanism by means of which this substitution is made is not known as yet, and the word 'mutation,' used in its broadest sense, will be applied in describing it. It is assumed, and experimental evidence supports this assumption, that reddish is an allelomorph of yellow which frequently 'mutates' to the wild type.

Mutations occur in females and only when the female is heterozygous, having reddish in one chromosome and one of its allelomorphs, wild or yellow, in the other. Frequency of mutations varies in different lines from 0 to 15 per cent.

108. *Mutations in Drosophila virilis and their bearing on the homology of genes*. ALEXANDER WEINSTEIN, Johns Hopkins University.

Three new mutations have occurred in *Drosophila virilis*: white eye and wee wing (both sex-linked recessives), and beaded wing (III-chromosome dominant with recessive lethal effect).

Of sex-linked mutations previously known in *virilis*, the following correspond in somatic effects and genetic relations to similarly named genes in *melanogaster*: yellow, scute, cross-veinless, singed, diminutive (dusky in *melanogaster*), magenta (garnet in *melanogaster*), and forked. Wee resembles miniature, but

it is just to the right of diminutive, while miniature is to the left of dusky. Possibly wee corresponds to dusky and diminutive to miniature, since all these characters are somewhat alike. But white fails to fall into position: in virilis, instead of being (as in melanogaster) just to the right of scute, it is beyond forked, at about 82. If, however, the virilis X be turned round, the genes white, forked, wee, diminutive, and singed correspond, respectively, to white, singed, miniature, dusky, and forked in melanogaster; and perhaps triangle in virilis and deltex in melanogaster can be added to this homology. Still other series of genes can be selected whose members correspond in somatic effects and genetic order. The data suggest that a rearrangement of genes has occurred in the course of evolution; but as the two species do not cross, it is impossible on the basis of the present data to decide definitely which genes are homologous.

The homologies of autosomal genes are even less certain than those of sex-linked genes.

109. *An interracial cross in Drosophila obscura producing partially fertile hybrids.*

D. E. LANCEFIELD, Columbia University.

A stock of *Drosophila obscura* from Eugene, Oregon, appears identical with older stocks, but crosses to them with difficulty. Successful matings in either direction occur once or twice in twenty attempts. The hybrid males are sterile, and those from Eugene mother have small testes. The hybrid females can be back-crossed with some difficulty to males of either race with the following results:

Varying sex ratios are obtained.

Half the sons have very small testes.

In either back-cross the sons with minute testes receive their single X-chromosome from the race not used in the back-cross.

These males with small testes are sterile, but those with normal-size testes may be fertile.

Crossing over is greatly reduced at both ends of X-chromosome.

Sterility of the hybrids is largely due to the incompatibility of a mixture of chromosomes of the two races.

A few repeated back-crosses of hybrid females in the same direction give perfectly fertile males and females.

The two races differ morphologically only in the size and shape of the Y-chromosome.

110. *Chromosome behavior in Sciara (Diptera).* C. W. METZ, Carnegie Institution.

Study of four species has brought out following features: Females possess four pairs of chromosomes and males same four pairs plus two larger chromosomes. In females chromosomes are closely associated in pairs (ovarian cells). In males chromosomes are not conspicuously associated. Apparently no synapsis occurs in spermatogenesis. First spermatocyte division appears to be monocentric, with all chromosomes attached by spindle fibers to this pole. Chromosomes do not divide at this division. Two large sex-limited chromosomes and four others pass to the visible pole, showing normal anaphase behavior. Re-

maining four pass away from this pole, diverging until they approach periphery of cell where they are deflected and begin to converge. Finally come together at point opposite the visible pole. These chromosomes show fiber attachments at posterior ends, not at anterior. V-shaped chromosome goes backward, two arms preceding the apex. The group of six chromosomes remains in cell, other is cast off in bud. Second division shows ordinary bipolar spindle. Five chromosomes (including both sex-limited ones) divide normally. Sixth splits, but both halves go to one pole. This pole remains in spermatid, other is budded off. All spermatids receive both sex-limited chromosomes. Females must be fertilized to give offspring. Facts suggest as tentative working hypothesis that females are produced by gynogenesis (sperm merely stimulating eggs) and males bisexually, and that in males maternal chromosomes are qualitatively different from paternal ones and possibly are cast out at first spermatocyte division.

111. *The non-functioning of the genes in spermatozoa.* H. J. MULLER AND F. SETTLES, University of Texas.

Comparison of sex ratios of over 4000 *Drosophilae* derived from fresh sperm with those of 1500 derived from sperm that had been retained over one week in the body of the female at 26°C. showed no significant difference. A few flies were obtained from sperm that had been retained in the female over three months at 10°C.; these also showed a normal sex ratio. These results (obtained in the winter of 1924-1925) prove that the genes distinctive of the X-chromosome do not function, while in the spermatozoa, to maintain the life and activity of the latter. It was also proved, by specially designed crosses (in a total count of over 4500 flies), that absence of an entire section of the second chromosome ('Translocation I') did not reduce the viability and activity of spermatozoa so constituted, as compared with normal spermatozoa, since neither increased age of sperm nor treatment with x-rays, nor both conditions together, caused a decrease in the number of flies from deficient as compared with normal spermatozoa. The conclusion follows that the genes in spermatozoa (unlike those in pollen) are in a dormant condition, the cytoplasm of the spermatozoa functioning like a watch running down and utilizing only material produced during the operation of the prematuration diploid nucleus. Selective action by either natural or artificial agencies, discriminating between spermatozoa of a given individual on the basis of their genetic composition, would hence be impossible, except in cases where there is an associated morphological difference between the spermatozoa.

112. *Human blood groups, their inheritance and racial significance.* L. H. SNYDER, North Carolina State College. (Introduced by W. E. Castle.)

No abstract.

113. *Dementia praecox in identical twins.* G. H. PARKER, Harvard University.

Two pairs of twins are reported, both suffering from dementia praecox. The first pair is that of boys showing striking physical similarities. The second is that of two mature women, both of whom were overtaken by the disease in early youth. Even in advanced age the two women are strikingly alike. In consequence of similarity of sex and of bodily configuration, each pair of twins is believed to consist of identical members, and the germinal nature of dementia praecox is thereby reaffirmed.

114. *Genetics and morphology of some endosperm characters in maize.* P. C. MANGELSDORF, Connecticut Agricultural Experiment Station.

Defective seeds are lethal or semilethal characters affecting the normal development of the seed. These characters are most frequently encountered when maize is inbred, and it is estimated that, in ordinary varieties, one plane in every thirty carries a factor for defective seeds in its germ plasm. Fourteen stocks segregating for defective seeds have been crossed in seventy-four combinations, and no two which are genetically alike have yet been found. Histological studies show that normal fertilization apparently occurs in the formation of embryo and endosperm. Both structures develop very slowly, however, and remain rudimentary. Both are affected to almost the same degree by the influence of the lethal factors. The relative development of the fourteen types of defective seeds, as compared to normal seeds on the same ears, ranges from 2.4 to 59 per cent.

115. *A genetic interpretation of ecological adaptation.* KARL SAX, Maine Agricultural Experiment Station.

In a cross of a small white bean and a large yellow 'eyed' bean some correlation was found in F_2 between yield and simple mendelizing characters, such as seed-coat color and pattern, indicating the presence of yield factors in specific chromosomes. In F_3 the mottled segregates were more productive than the self-colored or white segregates, but all classes were relatively unproductive. Under very favorable conditions in F_4 , the white segregates were most productive. The seeds of each F_4 plant were divided, and half of the seed of each F_4 sent was planted in a favorable location and the other half was planted in an unfavorable location in 1925. Both classes were moderately productive. In both cases the mottled segregates were more productive than the whites, although the difference was greater in the productive lot. Under the unfavorable conditions, the self-colored segregates were more productive than the whites, while under the favorable condition the self-colored segregates were less productive than the whites. This variation in relative yield of various classes of segregates under different environmental conditions is thought to be due to a differential response of factors for yield located in the chromosomes which carry the factors effecting differences in pigmentation and pattern. The adaptation of agronomic varieties to certain sections of the country might be explained on a similar basis.

116. *Heteroploidy and somatic variation in Dutch flower bulbs.* W. E. DE MOL, Columbia University.

A. Somatic variation without change of chromosome garniture: I) Somatic variation of the flower color. In hyacinths, heteroploid varieties produce bud variations in which the anthocyanin appears in the epidermis instead of in the subepidermis, the blue color changing into light violet. In tulips, carotinoids as well as anthocyanin play a part in somatic variation; sectors are found in which form and color are different from the mother variety. In Narcissi where there is no anthocyanin and where the color is in the chromoplasts, variations in color are taking place in the carotin of the chromoplasts. II) Somatic variation of form. Hyacinths occurred in which the organs of the plant are much elongated. In tulips, besides parrot forms, appear very primitive-shaped flowers. In Narcissi, there is splitting of the corona and phenomena connected with it.

B. Somatic variation with changing of chromosome garniture: In hyacinths hypotriploid forms arose from triploid varieties characterized by eighteen and twenty-one chromosomes in the vegetative nuclei. These somatic variations change the flower color from blue into red. In tulips such facts were not found. In Narcissi tetraploid forms originated from diploid hybrids between *Narcissus pseudonarcissus* and *Narcissus poeticus*.

117. *The instability of so-called bacterial species, with special reference to microbic dissociation and the action of the bacteriophage of d'Herelle.* PHILIP HADLEY, University of Michigan.

In recent years evidence of instability of so-called bacterial species has rapidly increased so that systematic bacteriology is in a precarious position. The question arises whether any order exists amid the disorder. Author believes some of the observed incongruities are due to operation of one or both of two newly recognized forces; one, operating from within, manifests itself in what is now termed 'microbic dissociation'; the other, operating from without, is the bacteriophage of d'Herelle. Both accomplish modifications of fundamental importance.

Microbic dissociation involves splitting off from a 'normal' stock (S) an apparent mutant (R). It is doubtful if R can give rise to S. S- and R-types differ from each other in fundamental cultural, morphological, biochemical, and immunological characteristics.

Both S and R, in turn, are susceptible to action of bacteriophage. Under its influence, from S can be derived a new type, SR; similarly, from R can be derived a new form, RR. Both SR and RR are resistant to lysis by the same bacteriophage. They differ from S and R in fundamental characteristics; they also differ from each other. Both SR and RR may be further modified, however, by a different bacteriophage into SR² and RR².

Author concludes at least part of observed bacterial instability depends on definite laws of change which run in parallel through many bacterial forms, and which are open to laboratory study. It is suggested that the initiation of such investigations for the purpose of ascertaining the limits of variation or mutation among bacteria offers the surest path to understanding what a bacterial species really is, if indeed it exists at all.

118. *Sex in a fraternity of pigeons obtained from an interfamily cross.* OSCAR RIDDLE, *Station for Experimental Evolution.*

Matings of pigeons of different zoological families have already been shown to be partially fertile and to yield all or nearly all male offspring. This found in matings of several different species. The present case involves a cross of common pigeon and ring-dove. Earlier matings of this cross by Whitman yielded 49 males: 0 females (seven matings), and three such matings by the writer gave 12 males: 0 females.

A specially fertile and successful mating of these particular species was obtained during 1923. Twenty-four of twenty-eight eggs produced were fertile; nineteen offspring developed to a stage suitable for sexing (all had testes); hatches were obtained from eleven consecutive eggs; fourteen lived to maturity, were all given special care and study, and while healthy were simultaneously killed for microscopic study.

The gonads proved to be exclusively testicular in nature, with sperm present, in all of the fourteen cases thus examined. Two of these 'males' had well-formed left oviducts. Evidence was obtained indicating that six of these fourteen sperm-producing 'males' were zygotic females. A calculation of probabilities from the numbers involved in this mating further assists the demonstration of sex reversal in these offspring: nineteen males from twenty-four eggs is to be expected to occur once in 395 trials. The origin of eleven males from eleven successively produced eggs in such a series would be expected to occur only once in 9384 trials. Both of these expectations were realized in this same series—the first case in which as many as twenty-four eggs were fertilized.

By title

119. *Genetic linkage in the tomato.* JOHN W. MACARTHUR, University of Toronto and Ontario Agricultural College.

The writer has attempted to assemble and cross in all combinations for theoretical and practical uses varieties of *Lycopersicum* differing in fruit size and shape and other more qualitative characters. From F_2 data on some 7000 plants apparently independent inheritance was established between most of the clearly segregating factors (also between yellow foliage and locule number, by others reported as completely linked). Linkage was, however, indicated between some qualitative size and shape factors.

The first linkage group involves three pairs of factors: Smooth-peach fruit surface (P,p), tall-dwarf stem (D,d), and 'round'-pear fruit shape (Pr,pr). The three sets of possible intercrosses gave the following results:

1. Dwarf smooth $\times$ tall peach. F_1 , tall smooth, DP. F_2 , phenotypes: 251 DP, 110 Dp, 107 dP, 0 dp.

2. Dwarf 'round' $\times$ tall pear. F_1 , tall 'round,' DPr. F_2 : 106 DPr, 59 Dpr, 57 dPr, 1 dpr.

3. Peach 'round' $\times$ smooth pear. F_1 , smooth 'round,' PPr. F_2 : 247 PPr, 125 Ppr, 122 pPr, 4 ppr.

By calculation of the association coefficients and interpolation of ratios in the repulsion series (including additional data from dwarf $\times$ pear crosses) approximate cross-over percentages were derived: 0 per cent between p and d, 16 per cent between d and pr (Hedrick and Booth found 17 to 20 per cent), 17 per cent between p and pr. Apparently the order of the genes is: p-d - - - pr. Their loci and others are being studied further from back-crosses.

120. *A spontaneous chimera in the tomato.* JOHN W. MACARTHUR, University of Toronto and Ontario Agricultural College.

Among 8000 tomato plants there appeared a foliage color mutation in one of 294 F_2 individuals from the cross of two fully green varieties, Yellow Pear and Dwarf Aristocrat.

When pricking out the seedlings an odd one was noted, one half full green and the other half strikingly yellowish-white. The chlorophyll deficiency involved one entire branch, leaves and stem alike, and extended narrowing downward on the main stem to a point just above ground, where a cell had presumably undergone a somatic mutation. Subsequently, the slow-growing white branch developed

only white secondary branches, foliage, sepals, immature fruit (and seedlings when bred), while the green branch continued normal and soon overspread the white. New branches, however, developing from the intermediate junction zone, proceeded to split into all-green, all-white, and mixed chimeric branches with varying amounts of the two component tissues. Stems, leaves, leaflets, peduncles, sepals, and unripe fruits often display the two colors in juxtaposition, sharply distinct in longitudinal stripes, sectors, or patches, each component in unbroken continuity, but seemingly distributed at random according to the fortunes of growth.

Flowers of all the branches possessed equally good pollen and ovules, and, whether selfed or crossed, naturally or artificially, set heavily with fruit which ripened all to the same rich red color. Seedling genetic behavior is being studied.

- 121.¹ *A geographical study of variation in two species of iris.* EDGAR ANDERSON, Missouri Botanical Garden. (Introduced by G. T. Moore.)

No abstract.

- 122.¹ *The expression of mendelian factors in the gametophyte of maize.* D. F. JONES AND P. C. MANGELSDORF, Connecticut Agricultural Experiment Station.

An endosperm character, defective seeds (de_1), is inherited as a simple recessive and normally gives 3:1 ratios. In certain crosses, however, the ratio is distorted, and approximately 32 per cent instead of 25 per cent recessives are found. This distortion is believed to be due to a mendelian factor (Ga), linked with the de_1 factor, which has its expression in the male gametophyte, speeding up the rate of pollen-tube growth and enabling the gametes which receive it to accomplish fertilization more frequently than by random assortment. When an F_2 progeny giving 32 per cent recessives is selfed, 'high,' 'normal,' and 'low' ratios are obtained in F_3 . This situation is similar to that found in a cross between Squirrel Tooth Pop and Sugary, in which 16 per cent recessives occur in F_2 , and 'high,' 'normal,' and 'low' ratios are encountered in F_3 . The su and de_1 factors are linked, and it is probable that the gametophyte factor in both stocks is the same. On such an assumption the position of the Ga factor in relation to the de_1 and su loci has been determined and the relative effectiveness of the two types of gametes in accomplishing fertilization has been calculated.

- 123.¹ *A study of pollen-tube growth in relation to sterility between two species: Datura stramonium and Datura metaloides.* J. T. BUCHHOLZ AND A. F. BLAKESLEE, University of Arkansas.

The pollen tubes of each species in self-pollinations or in sib crosses and in reciprocal crosses between these species were studied by a technique previously described. Good-sized flowering branches of each plant were cut under water and placed in an underground cave which maintained a constant temperature of 63°F. Pollinations were made after an interval of twelve to fourteen hours from the time of cutting and castration, about six to eight hours after the anthers on similar plants in the garden began to shed their pollen. The styles of these flowers were gathered and killed and microscopic slides prepared, from which measurements were made on the distance of pollen-tube penetration.

Results showed an average velocity of 2.45 mm. per hour for the pollen tubes of *Datura stramonium* selfed or in sib crosses. There was no detectable acceleration or retardation in the rate of pollen-tube growth in this compatible pollination, and selfs behaved the same as sibs. During germination and the first few hours following, an increase in growth rate is evident, but when a maximum velocity is attained, this growth rate holds for subsequent periods of growth. The ovary was reached in twenty-three to twenty-six hours, depending upon the length of the style.

The pollen tubes of *Datura metaloides* selfed or sibbed gave an average growth rate of 2.34 mm. per hour, with no marked change in rate after the first few hours, when a maximum velocity was attained. Our observations show a very slight retardation after two days, not to be regarded as significant. The ovary was reached after about seventy hours at 63°F. in this species, which has a style exceeding 16 cm. in length.

Flowers of *Datura stramonium* pollinated with pollen of *D. metaloides* gave a growth rate of 2.14 mm. per hour. The increase in rate of growth accompanying and following germination was more marked. The pollen grains are slower in germinating and in attaining their velocity, but there was no acceleration or retardation at a later period in this cross between the two species. The ovary was reached in twenty-seven to thirty hours, while abscission of the style does not take place until several days later. Seed capsules were set by this cross, but the seeds were all empty. Obviously, the sterility of this cross is due to a failure of the egg and sperm to unite in forming a zygote, or to embryo or endosperm abortion.

In the cross *D. metaloides* × *D. stramonium* the pollen tubes germinate and grow very slowly—less than 0.4 mm. per hour, and exhibit great variability. Here we find slow pollen-tube growth as a primary cause of the interspecific sterility, for the style would drop off long before these pollen tubes could reach one-half the distance to the ovary.

Acceleration in pollen-tube growth is not an index of compatibility in *Datura*, and we have not found a retardation in crosses between incompatible species. We have observed other characteristic abnormalities in incompatible pollen tubes, which may serve as an index of incompatibility.

124.¹ *Genetic linkages between size and color factors in the tomato.* E. W. LINDSTROM, Iowa State College.

From a large number of varietal crosses in tomatoes, involving different sizes of fruits and the two pairs of color factors (*Kr* controlling red and yellow flesh color and *Yy* determining yellow and colorless epidermis), certain correlations or linkages have been found to exist between these quantitative and the qualitative types of hereditary characters. The manner in which the crosses were made precludes any explanation in terms of a direct physiological correlation between color and size. Accordingly, the linkages are thought to be genetic in nature, caused by the fact that the same chromosome bearing certain color factors also carries definite size factors. In other words, both the *R* and *Y* chromosomes in certain varieties of tomatoes carry major-size factors. This is interpreted to mean that size inheritance is controlled by the same mechanism of heredity that so ably accounts for color (qualitative) heredity.

125.¹ *Sex expression in spinach.* J. T. ROSA, College of Agriculture, Davis, California.

The plants are generally dioecious, though some are monoecious. Staminate plants are smaller, send up seed stalks earlier, flower earlier, have a shorter flowering period, and die earlier than pistillate or monoecious plants. The sex ratio is approximately 1:1. Sex expression and the sex ratio are not affected by environmental factors, as poor or rich soil, full or reduced light, wide or close spacing, time of planting, or mutilation.

Monoecious plants self-pollinated produce only monoecious progeny. Pistillate $\times$ monoecious plants produce pistillate and monoecious plants in the F_1 . Pistillate $\times$ staminate plants produce approximately equal numbers of those forms in the progeny. Small deviations from the 1:1 ratio in commercial strains may be due to the irregular inheritance of sex in the few monoecious plants existing in such strains or to lethal factors.

126.¹ *Sex in plants compared with sex in animals.* H. W. RICKETT, University of Missouri.

In many plants reproduction is associated with an alternation of diploid and haploid phases. Sexual bodies are associated with the haploid phase, and the diploid is commonly said to be asexual. In most animals the sexual cells themselves are the only haplonts, and sexual characters are associated with the diploid body. In plant diplonts there are also differences correlated with sexual differences, and associated with heterospory. These correspond to the sexual differences in animals, and can therefore be properly spoken of as sex differences. If the word sex is to be applied in the ordinary way to animals, it is questionable whether it is wise in teaching to use the same terminology to apply to those stages of plants that have no analogy in animals.

The ordinary animal is of one sex. Much evidence exists to show that both sex potentialities are present, only one expressed. In the higher plants, both sex potentialities are commonly expressed, and even in the dioecious seed plants there is evidence to show that both possibilities are present.

127.¹ *The effect of selection on spore size in pure lines of Helminthosporium.* C. D. LARUE, University of Michigan.

The work discussed here was done as a check on the author's results on selection within pure lines of *Pestalozzia*. *Helminthosporium* is, like *Pestalozzia*, a genus of the Fungi imperfecti, and has many characteristics which recommend it for selection studies. It is easily grown and it fruits readily and abundantly. Selections were made for thirty generations. Spore length was used as the basis of selection. At the end of the experiment, no distinct strains were demonstrable: the clone selected for long spores was exactly like that selected for short spores, and this in turn was identical with an unselected clone.

128.¹ *One hundred 'mutants' in the genus Fusarium.* L. H. LEONIAN, West Virginia Agricultural Experiment Station.

While working on the physiological taxonomy of some 500 cultures of *Fusarium*, the writer observed and separated over 100 'mutants.'

Colorless forms have given rise to colored strains (usually blue, blue-green, purple, pink, and yellow), and colored species have given rise to colorless fungi. Organisms with an abundance of aerial hyphae have produced strains with no aerial hyphae; sporodochia formers have yielded organisms which form no sporodochia and vice versa; very rapid growers have produced very slow growers; acid formers have yielded alkaline formers and neutral strains or vice versa; species able to digest casein have split into forms which are unable to digest casein; organisms thriving on very acid media have formed strains which make no growth on such media; spore producers have thrown off sterile forms, and an organism strongly pathogenic on bean has yielded a strain which is not pathogenic on this host.

Many of these forms breed true one generation after another and behave as true mutants. Numerous others, however, oscillate back and forth indefinitely; one type appearing for a generation or two, then reverting back to the former type, again to change into the new form a generation or two later. All attempts to fix the type in these reverting forms have given negative results. It seems that two distinct organisms complete the life-cycle of a complex species.

In most cases mutations are not discontinuous, but may appear as often as the organism is propagated; in case of others this is not quite so frequent. A single species may form from one to as many as six distinct 'mutants' in which all sorts of intergradations may be seen.

All of these organisms have come from single spores and have developed no sexual phase during their growth. In fact, many of these organisms do not possess, so far as our knowledge is concerned, any sexuality in their life-cycle.

129.¹ *The frequency of mutation in maize.* L. J. STADLER, Bussey Institution.

No abstract.

130.¹ *Primary and double chromosomal types in the offspring of triploid daturas.*

A. F. BLAKESLEE AND GORDON MORRISON, Carnegie Institution.

A 1n plant (A), discovered in our line 1, produced 2n offspring by non-reduction. From these was obtained a 4n individual. This $4n \times 2n$ gave a 3n. Since all these types (included in line 1A) trace their origin to a single haploid, they are genetically comparable.

Triploids (3n), whether selfed or crossed with 2n, throw normal 2n, primary ($2n + 1$) and double ($2n + 1 + 1$) types in their offspring. In a culture of over 1000 offspring from a triploid, eleven of the theoretically possible twelve primary types have been obtained in relatively high numbers, as well as thirty-one of the fifty-five theoretically possible ($2n + 1 + 1$) types which may be considered combinations of these eleven primaries.

Photographs of capsules of the double mutants show the resultant effect of the factors in their two extra chromosomes.

131.¹ *Inheritance of plumage color in the Rhode Island Red breed of domestic fowl.* F. A. HAYS, Massachusetts College of Agriculture.

Experiments carried over three years at the Massachusetts Agricultural Experiment Station show that Rhode Island Red plumage color is rather complex

genetically. Three genes are of chief concern to the breeder of 'standard' color. Reddish-brown pigment depends upon the presence of autosomal gene B, which is epistatic to gold (s). Gene B acts only in the presence of either or both of the other genes studied. Gene L is sex-linked and modifies distribution and intensity of brown pigment. Gene E has already been described by others as an autosomal gene concerned in the distribution of melanic pigment. The presence of factor E is not essential in producing the color desired. The desired shade of red in males depends upon the presence of gene B in homozygous condition and upon gene L either as a homo- or heterozygote. Females can carry L only as heterozygote, it being sex-linked. True-breeding males should carry both genes in homozygous condition. Gene E is responsible for smut in undercolor and stippling in various body regions. It should not be carried by either males or females used for breeding.

Several other genes described by other workers are normally present in Rhode Island Reds. Gene C for pigmentation as described by Hadley is here concerned. Gene em for Columbian pattern as described by Dunn is also normally present. Lippincott's gene R for restriction of pigment and shape of pigment granules is present in blue-smut birds, but not in black-smut birds.

132.¹ *Five new color factors in guinea-pigs.* HEMAN L. IBSEN, Kansas State Agricultural College.

1. Fading factor: It is especially noticeable in *Cd Ca* yellows, which, several months after birth, fade as a result into what the fanciers call a 'cream.' It behaves as a recessive to non-fading.

2. Darkening factor: *CdCa* yellows carrying this factor are cream at birth and gradually become more intense. At maturity they are deep yellow (not red). It is not known yet how it behaves toward its allelomorph, but it seems to be epistatic to the fading factor.

3. White tipping (*W*): It is a special modifying factor, present at birth, acting almost exclusively on chocolate hairs, and is incompletely dominant to its allelomorph. *WW* chocolates are very white-tipped, the males more so than the females. A few *WW* blacks have been produced which show only a small number of white-tipped hairs. The factor has no noticeable effect on red hairs.

4. Black tipping: It has been observed in reds and in dark-eyed whites (*PP Cr Cr ee*). The hairs are tipped with either black or chocolate, depending on whether the animal carries black (*B*) or its allelomorph, *b*, chocolate. It generally appears from six months to eighteen months after birth and gradually becomes more pronounced. Females generally show the character earlier and more markedly than males.

5. Kodak. It has been found thus far only in animals of the composition *pp ep (ep or e) Cr Cr*. They are pink-eyed whites at birth and gradually acquire black or chocolate pigment in their hair, the completed process taking at least four months. The factor is recessive.

133.¹ *Effect of ovarian injury on egg laying in fowls.* MORRIS STEGGERDA, University of Illinois. (Introduced by Charles Zeleny.)

Trap-nested records were kept of fowls whose ovaries were mutilated in various ways. It was found in three successive years that pullets having a portion of

their ovary removed, or those whose ovary was badly cut, laid as well as control birds. There were in the experiments 100 fowls, fifty acted as controls and fifty as operated birds. It was apparent also that the operation caused a greater variability in egg laying among the operated birds, for in each experiment the highest and the lowest of the entire pen were operated fowls. If the highest one-third of all the operated birds is compared with the highest one-third of all the control fowls, we find that the operated series yields an average per bird of 187 eggs, while the average of the controls is 168 eggs, or a difference of 19 eggs each in favor of the operated series. When the same comparison is made for the lowest birds of each group, we find that the operated birds lay an average of 92 eggs, while the controls lay 108 each, or a difference of 16 eggs each in favor of the controls. Our interpretation of this variability is that in some cases the operation produces a stimulating effect upon egg production, while in others the physiological condition of the bird is so disturbed by the operation that the egg-laying ability is impaired. Such factors as weight, mortality, fertility, broodiness, and the dates of the first eggs were apparently not affected by the operation.

134.¹ *Evidence of somatic segregation of factors for plumage color in heterozygotes in the turkey.* W. R. B. ROBERTSON, University of Missouri.

The black-bronze heterozygote, for the most part a black bird, shows a few isolated bronze-type or part-bronze-type feathers. In the part-bronze-type feather one side or a portion of one side may be of the bronze pattern, the remainder black. Occasionally two, three, or even four totally bronze-type feathers may occur together. Evidently the factor for black has been dropped in such cases and the recessive factor for bronze is permitted to appear. Homozygous blacks show no such bronze or part-bronze-type feathers.

'Blue,' 'slate,' and 'buff' breeds of the turkey have a dominant autosomal factor for dilution of black pigment which is independent of the allelomorphic series, black, bronze, Narragansett, Bourbon red. In combination with black, black-bronze, or black-Narragansett, it produces the 'blue' turkey; with homozygous bronze or bronze-Narragansett, the 'slate' turkey; with Bourbon red, the 'buff' turkey. Heterozygotes for this dominant dilution factor show likewise a dropping of the factor. The color in such spots is that of the hypostatic black, black-red, bronze, bronze-red, etc., which the 'blue' or 'slate' bird may carry.

In 'blue' birds that are black-bronze heterozygotes a few non-blue feathers appear that are identical with the feathers of the 'slate.' This indicates that the black factor continues to be dropped regardless of the presence of the dilution factor.

The above cases might be explained as the result of non-disjunction of the daughter halves of chromosomes carrying such dominant factors at some previous somatic mitosis either early or late in the ontogeny of the feather germ.

135.¹ *Non-inheritance of the temperature effect on bar eye in *Drosophila melanogaster*.* CHARLES ZELENY, University of Illinois.

The number of facets in bar eye is strikingly affected by the temperature of the developing larvae as well as by several known hereditary factors. Since the somatic effect of the environmental factor is similar to that of the hereditary

ones, it has seemed desirable to find out if differences in hereditary constitution may be brought about by continued subjection to different temperatures. In an inbred selected stock of bar eye with a known history, the descendants of a single pair were divided into two groups, one kept at 17°C. and the other at 27°C. The facet number of the first group is approximately two and a half times that of the second. By means of reciprocal transfers from one temperature group to the other, it is possible to test each for the appearance of germinal changes. Four such tests have been made, the last being after sixty-four generations at 27°C. and twenty-six generations at 17°C., each group covering a period of about thirty months. So far no germinal changes have appeared which can be ascribed to the inheritance of the temperature effect.

136.¹ *Effects of ten generations of alcoholism upon albino rats.* F. B. HANSON, Washington University, St. Louis.

Ten generations of albino rats have received the treatment with alcoholic fumes. Both test and control animals are the direct descendants of a single pair of inbred rats. Sister-by-brother mating was practiced throughout.

Effects on birth weight: In four of the ten generations the mean average birth weight of the tests is greater than the controls, but in no case significantly greater. In the other generations the tests have a lower mean birth weight than the controls and in some of these generations the difference is greater than three times the P. E. of the difference.

Effects on litter size: In every generation except the first the test animals produce larger litters than the controls. In some generations this difference in favor of the tests is significant. There is a negative correlation between litter size and birth weight. The larger litters of the tests mean smaller individuals, hence the lesser birth weight as compared with the controls.

Effects on growth: At twenty days of age, the test rats are equal in body weight to the controls. At this age treatment began and its effect was to depress the growth curve. This slower growth rate is never transmitted. Each of the later generations again produces young that at twenty days of age are as heavy as the controls.

The grandchildren of the tenth treated generation show no greater resistance to alcoholic fumes than the corresponding control generation.

137.¹ *Alcohol and the sex ratio.* FLORENCE HEYS, Washington University, St. Louis. (Introduced by Frank Blair Hanson.)

The paper deals with the effect of alcohol upon the sex ratio in albino rats and is based on data covering ten successive generations of control and treated animals. All of the 3123 animals included were derived from a single pair of Wistar Institute rats. Sister-by-brother mating within the litter was employed throughout the experiment.

Treatment was administered by the fume-tank method, commencing at twenty days of age, and continuing daily until one hundred days of age, when the rats were mated. Sex ratios were taken at birth and verified at twenty days.

The difference divided by the probable error shows that in none of the ten generations is the difference in sex ratio between treated and control of statistical significance. In nine of the ten generations the relation of the difference to its probable error is wholly negligible.

In the totals for the ten generations the number of animals is very large with sex ratios of correspondingly low probable errors which may account for the fact that the difference in sex ratio for the totals just approaches significance, being 3.07 times its probable error.

The data as a whole indicate that severe and prolonged administration of alcohol fumes does not have a differential effect upon the sex ratio of the albino rat.

138.¹ *Studies of inheritance in Stagmomantis carolina.* EVERETT H. INGERSOLL, Kansas Agricultural Experiment Station. (Introduced by R. K. Nabours.)

Eleven females of *Stagmomantis carolina* (Johannson) which had mated in nature, male unknown, gave 57 recorded offspring (29 males and 28 females). There were 76 offspring (41 males and 35 females) recorded from three matings in which both parents were known.

Records were made of the colors of the eyes, body, legs, wings, and ocelli which were gray, green, pink, dark cinnamon, avellaneous, and dark cinnamon plus olive-gray. In the eye colors, gray appears to be dominant to green, and to grayish pink. Green body color is a recessive, and gray is recessive to avellaneous body color. In Kanasis, *Stagmomantis carolina* has one generation a year. However, by refrigerating the egg cases, practically two generations a year may be obtained. These mantids are difficult to rear on account of their predaceous habits.

139.¹ *Parthenogenesis in the grouse locust, Paratettix texanus Hancock.* ROBERT K. NABOURS AND MARTHA E. FOSTER, Kansas State Agricultural College.

Among 2479 matings of *Paratettix texanus* Hancock, fifteen gave eighty-two recorded offspring, which were, with one exception, females, showing exclusively the segregate and crossover patterns of the female parents and no trace of the contrasting dominant color patterns of the males as invariably occurs when the male takes part in the parentage. Eleven offspring, from five of these matings, were successfully tested and found to be homozygous for the dominant maternal patterns. Following this observation, a number of female nymphs were separated from the males. Of the 107 females which became adult, 47 produced 409 offspring, of which 280 (279 females and 1 male) became large enough to be recorded. The patterns of these parthenogenetic offspring, with two possible exceptions, were those that would be expected from the non-crossover and crossover gametes of the parents.

In *Paratettix texanus* segregation and crossing-over of factors occur in individuals producing parthenogenetically apparently to the same extent as in those reproducing bisexually. A few of the parthenogenetically produced individuals gave, in turn, parthenogenetic offspring. Individuals gave offspring parthenogenetically and then, after being mated, produced considerable numbers bisexually. The females are very much more prolific when mated than when unmated.

140.¹ *The inheritance of horns, wattles, and color in goats.* J. L. LUSH, Texas Agricultural Experiment Station. (Introduced by L. J. Cole.)

No abstract.

AMERICAN SOCIETY OF ZOÖLOGISTS

CONSTITUTION, OFFICERS, AND MEETING PLACES OF THE SOCIETY

CONSTITUTION

ARTICLE I

NAME AND OBJECT

Section 1. The Society shall be called the "American Society of Zoölogists."

Sec. 2. The object of the Society shall be the association of workers in the field of Zoölogy for the presentation and discussion of new or important facts and problems in that science and for the adoption of such measures as shall tend to the advancement of zoölogical investigation in this country.

ARTICLE II

MEMBERSHIP

Section 1. Members of the Society shall be elected from persons who are active workers in the field of Zoölogy and who have contributed to the advancement of that science.

Zoölogists without the training in research required for full membership may be elected associate members of the Society.

Sec. 2. Election to membership in the Society shall be upon recommendation of the Executive Committee.

Sec. 3. Each member shall pay to the Treasurer an annual assessment as determined by the Society. This assessment shall be considered due at the annual meeting and the name of any member two years in arrears for annual assessments shall be erased from the list of members of the Society, and no such person shall be restored to membership unless his arrearages shall have been paid or he shall have been re-elected.

Sec. 4. Foreign Zoölogists, not members of this Society, may be elected Honorary Fellows upon unanimous recommendation of the Executive Committee by a majority vote of the members present at any meeting of the Society. Honorary Fellows shall not be required to pay dues.

ARTICLE III

OFFICERS

Section 1. The officers of the Society shall be a President, a Vice-President, a Secretary and a Treasurer and the members at large of the Executive Committee.

Sec. 2. The Executive Committee shall consist of the President, the Vice-President, the Secretary, the Treasurer and five members elected from the Society at

large. Of these five members, one shall be elected each year to serve five years. If any member at large shall be elected to any other office, a member at large shall be elected at once to serve out the remainder of his term.

Sec. 3. These officers shall be elected by ballot at the annual meeting of the Society and their official terms shall commence with the close of the annual meeting, except that the Secretary and the Treasurer shall be elected triennially and shall serve for three years.

Sec. 4. The officers named in Section 1 shall discharge the duties usually assigned to their respective offices.

Sec. 5. Vacancies in the board of officers, occurring from any cause, may be filled by election by ballot at any meeting of the Society. A vacancy in either the Secretaryship or the Treasurership occurring in the interval of the meetings of the Society may be filled by appointment, until the next annual meeting, by the Executive Committee.

Sec. 6. At the annual meeting the President shall name a nominating committee of three members. This committee shall make its nominations to the Secretary not less than one month before the next annual meeting. It shall be the duty of the Secretary to mail the list of nominations to all members of the Society at least two weeks before the annual meeting. Additional nominations for any office may be made in writing to the Secretary by any five members at any time previous to balloting.

ARTICLE IV

MEETINGS OF THE SOCIETY

Section 1. Unless previously determined by the Society the time and place of the annual meeting of the Society shall be determined by its Executive Committee. Special meetings may be called and arranged for by the Executive Committee. Notices of such meetings shall be mailed to all members of the Society at least two weeks before the date set for the meeting.

Sec. 2. Sections of the Society may be organized in any locality by not less than ten members, for the purpose of holding meetings for the presentation of scientific papers. Such sections shall have the right to elect their own officers and also associate members; provided, however, that associate membership in any section shall not confer membership in the Society.

ARTICLE V

QUORUM

Twenty-five members shall constitute a quorum of the Society and four a quorum of its Executive Committee.

ARTICLE VI

CHANGES IN THE CONSTITUTION

Amendments to this Constitution may be adopted at any meeting of the Society by a two-thirds vote of the members present, upon the following conditions:

(a) The proposed amendment must be in writing and signed by at least five members of the Society.

(b) This signed proposal must be in the hands of the Secretary at least one month before the meeting of the Society at which it is to be considered.

(c) The Secretary shall mail copies of the proposed amendment to the members of the Society at least two weeks before the meeting.

BY-LAWS

DUES

(1) The annual dues for members or associate members, unless remitted or changed by the vote of the Society, shall be two dollars.

SECRETARY

(2) The duties and privileges of the Secretary shall be as follows:

(a) He shall keep the records of the Society.

(b) Whenever the proper officers of a number of related societies shall have a conference with a view of determining a common time and place for the several annual meetings, he shall act as the delegate or representative of this Society. (See also 5.)

(c) He shall employ a typewriter or printer whenever in his judgment such employment will expedite the business of the Society, and

(d) He shall be reimbursed out of the funds of the Society for expenses incurred in attending meetings of the Society.

TREASURER

(3) The duties and privileges of the Treasurer shall be as follows:

(a) He shall be in charge of the funds of the Society.

(b) At the Annual Business Meeting of the Society he shall present a statement to date of the funds of the Society.

(c) He shall employ a typewriter or printer whenever in his judgment such employment will expedite the business of the Society.

AUDITING COMMITTEE

(4) The President shall annually appoint an auditing committee of two, who shall audit and report upon the financial record and statement of the Treasurer at the meeting for which they were appointed.

(5) The National Research Council allows the Society three representatives on the Division of Biology and Agriculture. Of these three representatives, one shall be elected each year to serve three years. The method of election shall be the same as that used in the election of the officers of the Society.

MEETINGS

(6) It shall be the policy of the Society to hold meetings in both Eastern and Central-Western territory, and the distribution of the meetings between the two territories shall be determined in general on the basis of the representation of Eastern and Western members in the Society. See also 2-b.

PROGRAM RULES

(7) In matters relating to programs for annual meetings the following rules shall be observed:

(a) Papers shall be listed and presented according to subject matter in the following groups: 1. Comparative Anatomy; 2. Embryology; 3. Cytology; 4. Genetics; 5. Comparative and General Physiology; 6. Ecology, and 7. Miscellaneous, or other groups at the discretion of the Secretary.

(b) Whenever conditions require it the Executive Committee shall schedule two or more groups for the same hour and rearrange the program to bring together papers on subjects of more general interest for meetings of the whole Society. The Committee, however, is instructed to avoid conflicts as much as possible.

(c) Papers shall be listed in their respective groups in the order received. Each active member is entitled to fifteen minutes of the time of the Society at the annual meeting which he may use to present one or more papers personally, or he may use any or all of this time in introducing papers of non-members on the program. The Society recognizes, however, the right of the Genetics Section to make their own program rules in conjunction with the Genetics Section of the Botanical Society of America.

(d) All papers not read when called for as listed shall be placed at the end of the group list, and, if not read when called for the second time, they shall be read by title only.

(e) The titles of "introduced" papers shall be listed in the groups after the titles of papers to be read by members. Such papers shall be read by title only in case the entire program cannot be completed during four regular sessions for reading papers.

(f) Fifteen minutes shall be the maximum time allowed for the presentation of a paper.

(g) Abstracts of papers for publication in the proceedings of the Society must be handed to the Secretary or his representative before final adjournment of the annual meeting.

ASSOCIATE MEMBERS

(8) Associate members may become members of sections of the Society and are entitled to the journal privileges of members.

HISTORICAL REVIEW

A review of the historical antecedents of the present American Society of Zoölogists will be found in *The Anatomical Record* for January, 1917. The list of officers and meeting places of the present Society found in the same place is brought up to date and reprinted here.

LIST OF FORMER OFFICERS

AMERICAN MORPHOLOGICAL SOCIETY

<i>President</i>	<i>Vice-President</i>	<i>Secretary-Treasurer</i>
1890—E. B. Wilson		J. P. McMurrich
1891—C. O. Whitman	E. L. Mark	J. P. McMurrich
1892—C. O. Whitman	H. F. Osborn	J. P. McMurrich
1893—C. O. Whitman	E. B. Wilson	J. P. McMurrich
1894—C. O. Whitman	W. B. Scott	G. H. Parker
1895—E. B. Wilson	W. B. Scott	G. H. Parker
1896—E. L. Mark	H. F. Osborn	G. H. Parker
1897—C. S. Minot	S. I. Smith	G. H. Parker
1898—H. F. Osborn	T. H. Morgan	G. H. Parker
1899—E. G. Conklin	W. M. Wheeler	Bashford Dean
1900—T. H. Morgan	H. C. Bumpus	J. S. Kingsley
1901—J. S. Kingsley	E. A. Andrews	T. H. Montgomery
1902—H. C. Bumpus	G. H. Parker	M. M. Metcalf

Additional Members of the Executive Committee

1891—E. B. Wilson	1897—J. S. Kingsley
H. F. Osborn	Bashford Dean
1892—E. L. Mark	1898—C. B. Davenport
T. H. Morgan	F. R. Lillie
1893—T. H. Morgan	1899—J. P. McMurrich
C. B. Davenport	G. H. Parker
1894—E. A. Andrews	1900—F. R. Lillie
F. H. Herrick	Jacob Reighard
1895—T. H. Morgan	1901—C. F. W. McClure
S. Watase	C. W. Hargitt
1896—E. G. Conklin	1902—H. S. Jennings
William Patten	R. G. Harrison

AMERICAN SOCIETY OF ZOOLOGISTS

EASTERN BRANCH	<i>President</i>	CENTRAL BRANCH
G. H. Parker	1903	Jacob Reighard
E. A. Andrews	1904	C. H. Eigenmann
W. E. Castle	1905	F. R. Lillie
W. E. Castle	1906	C. C. Nutting
C. B. Davenport	1907	S. A. Forbes
W. M. Wheeler	1908	E. A. Birge
H. S. Jennings	1909	E. A. Birge
T. H. Montgomery	1910	C. E. McClung
H. V. Wilson	1911	George Lefevre
A. G. Mayer	1912	H. B. Ward
Raymond Pearl	1913	H. B. Ward

LIST OF FORMER OFFICERS

EASTERN BRANCH

Jacob Reighard
W. E. Castle
William Patten
William Patten
F. H. Herrick
H. S. Jennings
H. V. Wilson
H. H. Wilder
H. E. Crampton
G. A. Drew
Alex. Petrunkevitch

Vice-President

1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913

CENTRAL BRANCH

H. F. Nachtrieb
S. J. Holmes
William A. Loey
George Lefevre
H. B. Ward
M. F. Guyer
M. F. Guyer
H. F. Nachtrieb
R. H. Walcott
C. M. Child
C. M. Child

Secretary-Treasurer

G. A. Drew
G. A. Drew
H. S. Pratt
H. S. Pratt
C. J. Herrick
L. L. Woodruff
L. L. Woodruff
H. W. Rand
Raymond Pearl
J. H. Gerould
Caswell Grave

1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913

Frank Smith
F. R. Lillie
C. E. McClung
T. G. Lee
T. G. Lee
T. G. Lee
Charles Zeleny
H. V. Neal
H. V. Neal
W. C. Curtis
W. C. Curtis

Executive Committeemen

F. R. Lillie
T. H. Montgomery
H. C. Bumpus
H. S. Jennings
E. A. Andrews
W. R. Coe
G. A. Drew
M. M. Metcalf
D. H. Tennent
R. G. Harrison
H. E. Jordan
C. E. McClung

George Lefevre
T. G. Lee
Herbert Osborn
C. H. Eigenmann
J. G. Needham
S. J. Holmes
W. A. Loey
C. M. Child
R. H. Walcott
W. C. Curtis
Oscar Riddle
H. B. Ward
Chauncey Juday
H. W. Norris
C. E. McClung
H. F. Nachtrieb

AMERICAN SOCIETY OF ZOÖLOGISTS (AMALGAMATED)

<i>President</i>	<i>Vice-President</i>	<i>Executive Committeemen</i>
1914. C. E. McClung	M. F. Guyer	H. E. Jordan—1 year H. F. Nachtrieb—2 years H. V. Wilson—3 years George Lefevre—4 years A. F. Shull—5 years
1915. W. A. Locy	W. E. Ritter	D. H. Tennent
1916. D. H. Tennent	Charles Zeleny	R. P. Bigelow—5 years L. J. Cole—4 years
1917. M. M. Metcalf	Charles Zeleny	H. V. Wilson
1918. George Lefevre	L. L. Woodruff	M. M. Metcalf
1919. C. M. Child	H. H. Wilder	George Lefevre
1920. Gilman A. Drew	Caswell Grave	C. M. Child
1921. Charles A. Kofoid	Aaron L. Treadwell	G. A. Drew
1922. H. H. Wilder	Bennet M. Allen	C. A. Kofoid
1923. M. F. Guyer	Robert A. Budington	H. H. Wilder
1924. R. G. Harrison	R. K. Nabours	M. F. Guyer

Secretary-Treasurer

1914-1918. Caswell Grave
1918-1921. W. C. Allee

Secretary

1921-1924. W. C. Allee

Treasurer

1922. D. H. Tennent
1923-1924. Robert H. Bowen

*Representative in the Division of Biology and Agriculture,
National Research Council*

M. F. Guyer 1919-1921	G. H. Parker 1919-1922	F. R. Lillie 1919-1923
William Patten 1921-1924	H. S. Jennings 1922-1925	

Associate Editors of the Journal of Morphology

<i>1921</i>		
Gary N. Calkins	J. S. Kingsley	William Patten
<i>1921-22</i>		
E. G. Conklin	M. F. Guyer	W. M. Wheeler
<i>1921-23</i>		
C. A. Kofoid	F. R. Lillie	J. T. Patterson
<i>1922-24</i>		
G. A. Drew	H. V. Neal	L. L. Woodruff

AMERICAN SOCIETY OF ZOÖLOGISTS

OFFICERS FOR 1925

<i>President</i>	C. R. STOCKARD
<i>Vice-President</i>	C. R. MOORE
<i>Secretary</i>	D. E. MINNICH
<i>Treasurer</i>	L. B. AREY

Executive Committee

GILMAN A. DREW.....	1925
CHARLES A. KOFOID.....	1926
H. H. WILDER	1927
M. F. GUYER.....	1928
R. G. HARRISON.....	1929

Officers of Genetics Section

<i>Chairman</i>	H. H. BARTLETT
<i>Secretary-Treasurer</i>	D. F. JONES
<i>Representative of the Zoölogists</i>	R. K. NABOURS
<i>Representative on Board of Control of Botanical Abstracts</i>	H. J. MULLER
<i>Representative on Editorial Board of Journal of Heredity</i>	L. C. DUNN

Representative of the Society in the Division of Biology and Agriculture of the National Research Council

E. G. CONKLIN	1926
J. T. PATTERSON	1927
L. L. WOODRUFF.....	1928

Representatives of the Society on the Council of The American Association for the Advancement of Science

H. S. JENNINGS	M. H. JACOBS
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Representatives of the Society on the Council of the Union of American Botanical Societies

F. R. LILLIE	R. G. HARRISON
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Representatives of the Society on the Advisory Editorial Board of Biological Abstracts

H. S. PRATT, G. K. NOBLE.....	<i>Taxonomy</i>
D. H. TENNENT.....	<i>General Embryology</i>
M. H. JACOBS.....	<i>General Physiology</i>
R. H. BOWEN.....	<i>Cytology</i>

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AND PHYSIOLOGY

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To serve until 1927.....	A. A. SCHAEFFER HELEN DEAN KING S. O. MAST
To serve until 1928.....	H. B. WARD FERNANDUS PAYNE R. W. HEGNER

LIST OF PLACES OF MEETING

AMERICAN MORPHOLOGICAL SOCIETY

1890—Boston	1894—Baltimore	1899—New Haven
1891—Philadelphia	1895—Philadelphia	1900—Baltimore
1892—Princeton	1896—Boston	1901—Chicago
1893—New Haven	1897—Ithaca	1902—Washington
	1898—New York	

CENTRAL NATURALISTS

1899—Chicago	1900—Chicago
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SOCIETY OF AMERICAN ZOÖLOGISTS

1901—Chicago	1902—Washington
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AMERICAN SOCIETY OF ZOÖLOGISTS

EASTERN BRANCH	JOINT MEETINGS	CENTRAL BRANCH
1903—Philadelphia	1905—Ann Arbor	1903—St. Louis
1904—Philadelphia	1908—Baltimore	1905—(Mch.) Chicago
1906—New York	1911—Princeton	1907—(Mch.) Madison
1907—New Haven	1912—Cleveland	1907—Chicago
1909—Boston	1913—Philadelphia	1910—(Apr.) Iowa City
1910—Ithaca		1910—Minneapolis
		1912—(Apr.) Urbana

MEETING PLACES

1914—Philadelphia	1918—Baltimore	1922—Boston
1915—Columbus	1919—St. Louis	1923—Cincinnati
1916—New York	1920—Chicago	1924—Washington
1917—Minneapolis	1921—Toronto	1925—New Haven

THE PHYSIOLOGICAL SIGNIFICANCE OF THE CEPHALOCAUDAL DIFFERENTIAL IN VERTEBRATE DEVELOPMENT

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The apparent progression of growth and differentiation from the cephalic region posteriorly in development is of such general occurrence that it has often been called a law of development or growth. Most embryologists, however, have contented themselves with the formulation or recognition of the law, so called, and have concerned themselves but little with the question of its physiological basis and significance. In a recent paper in this journal, Doctor Kingsbury ('24) has presented an interesting discussion of this aspect of development, which he calls the "law of cephalocaudal differential growth." He concludes that the cephalocaudal progression in differential growth "expresses a time or age difference due to the mode of differential growth" (p. 318), but makes no attempt to analyze or discover a basis for this mode of differential growth. In the course of his discussion he takes up the question of the relation of cephalocaudal differential growth to physiological gradients and rejects the gradient conception as inadequate "for the explanation of the law of cephalocaudal differential growth" because of certain difficulties which he finds in its application to vertebrate development.

The writer believes that some of Doctor Kingsbury's difficulties are apparent rather than real. They seem to be due in considerable part to the fact that the data bearing on the question of the significance of the gradients for vertebrate development have appeared in different publications and

have never been brought together with special reference to vertebrate development. Some of the data concerned apparently have not come to his attention or possibly their significance has not been fully recognized.

Much further work is of course necessary as an adequate basis for a general consideration of vertebrate development from the gradient standpoint, but in the meantime the present paper will perhaps serve to call attention to some of the points which seem to be important and to correct some misunderstandings.

THE SIGNIFICANCE OF THE GRADIENTS IN GENERAL

Whatever theory of the origin of vertebrates we may accept, most of us probably believe that the physiological basis of polarity and symmetry is similar in invertebrates and vertebrates. The evidence for the existence of an axial gradient or gradients in the simpler organisms, both animal and plant, in many cases throughout life, and in the earlier developmental stages of many of the higher animals, including fishes, amphibia, and birds, is extensive and of many different sorts (Child, '24, chap. 7). As regards the question whether the gradient is actually the physiological basis of polarity and symmetry and not merely the expression of some more fundamental condition, it may be pointed out that in many of the simpler forms the gradient or gradients can be experimentally obliterated, either in isolated pieces, or in the earlier developmental stages, or in both, and that when a particular gradient is thus obliterated we can find no evidence of the presence of the polarity or symmetry corresponding to it. Any further development of the embryo or piece occurs as if that polarity or symmetry were absent. Both polarity and symmetry have apparently been obliterated in hydrozoa and echinoderms and dorsoventrality has been obliterated in the vertebrates (Child, '24, pp. 82, 83, 104-107) through the differential susceptibility of different levels of the gradient to various agents. One may, of course, believe that a 'latent' polarity and symmetry of some sort still exist

in such apparently anaxiate forms, but such belief represents rather what we call an act of faith than a scientific belief, since there is no evidence for it (compare Kingsbury, '24, p. 318).

On the other hand, new gradients can be determined by the differential action of various environmental factors, and when such new gradients arise new polarities or symmetries appear corresponding to them in further development (Child, '24, chap. 9). In these cases one is, of course, privileged to believe that the new gradients are merely the expression of some molecular or other change in structure, but there is no evidence in support of this view and much against it (Child, '23, '24, pp. 25-28). Since we find the gradients appearing in vertebrate development in the same relations to physiological axes as in invertebrates, we can scarcely deny them the same significance which they seem, on the basis of the evidence, to possess in the invertebrates.

Among the unsegmented invertebrates and in plants it has been possible to demonstrate in many cases that new regions of high physiological activity arise in consequence of physiological isolation and that they may become the dominant regions of new gradients and, under proper conditions, the apical regions or heads of new axes (Child, '24, chap. 10).

THE POLAR GRADIENTS IN THE ANNELIDS

We need not subscribe to the theory of annelid origin of the vertebrates in order to believe that the annelids, as the simplest segmented animals, must be of interest as regards the gradient situation in comparison with higher forms. In the polychetes thus far examined there is present at the beginning of development, exactly as in the vertebrates examined, a single gradient with high end apical and low end basal, but as the trochophore develops the posterior growing region arises, apparently in consequence of some degree of physiological isolation. As elongation occurs, this posterior growing region becomes the high end of a second gradient opposite in direction to the primary gradient (Child,

'17). In the earlier stages of segment formation and even after a considerable number of segments are present, the whole body length except the prostomium, the peristomium, and perhaps one or two following segments, all of which represent the extreme anterior end, are included in the secondary gradient with its high end posterior. But as nervous development progresses and the segmental ganglia become connected successively with regions anterior to them, we find a corresponding extension of the primary gradient, or, more strictly, the cephalocaudal gradient. One after another the segments are, so to speak, taken over by this gradient, and the region representing the junction of the low ends of the two gradients passes farther and farther posteriorly. In forms in which the posterior growing region persists throughout life the secondary, caudocephalic gradient also persists, but in those in which posterior growth and segment formation cease, the second gradient may disappear completely.¹

In many of the fresh-water oligochetes the secondary, caudocephalic gradient persists throughout life, and its high end, just anterior to the anal region, may be even higher than the head region in susceptibility (Hyman, '16). Various facts indicate that in such forms as these complete integration and subordination of the more posterior levels to the head region never occur. When the head region is quiet the region of the second gradient performs independent movements which are initiated and controlled from the posterior region. The respiratory movements of these forms, consisting of a rapid waving to and fro of the posterior half or more of the body which is protruded from the mud, are of this character. When the head is stimulated, these movements cease and the whole body length may, for the time

¹ For published data on the gradients in the annelids, see Child, '17; Hyman, '16; Hyman and Galigher, '21. Morgan and Dimon ('04) observed that both ends of the earthworm are electrically negative (galvanometrically) to the middle region and Hyman and Bellamy ('22) found double electric potential gradients and corresponding galvanotactic reaction in annelids.

being, undergo more or less complete subordination to the head region as regards motor behavior, but as the excitation subsides the posterior region again becomes independent or largely so. In some forms there is even a secondary enlargement of nervous structures at the posterior end. Such animals remain imperfectly integrated throughout life. Integration may be more or less complete during periods of excitation of anterior levels, but the caudocephalic gradient represents a more or less independent system when the anterior region is quiescent. The fact that the head develops first and the nervous system begins its development in the head region and differentiates progressively in the posterior direction constitutes the morphological basis of such dominance of the head region as exists, and there can be little doubt that this course of development is an expression of the primary gradient and of its extension.

The difference in physiological condition in the segments of the second gradient is of course primarily dependent on a difference in stage of development. The more anterior, earlier formed segments represent the lower levels, the more posterior, later formed, the higher levels. But it is evident that the difference in developmental stage is associated with a relation of dominance and subordination which is effective to some degree as long as the head region is quiescent. But with excitation of the head region the nervous impulses originating in the highly differentiated anterior region are more effective than the comparatively feeble dominance of the posterior growing region which is more or less embryonic. It is entirely possible that the direct dominance of the growing region extends only a very short distance and that at other levels of the secondary gradient the dominance is from segment to segment.

The gradients have been determined in developmental stages of a few arthropods, but the data have not been published. In the forms examined a second gradient with its high end in the posterior growing region arises in early development and persists during segment formation, as in the annelids, but disappears later.

THE GRADIENTS IN VERTEBRATE DEVELOPMENT

According to the facts thus far available, vertebrate and annelid development are very similar as regards the gradient relations. Development begins with a single cephalocaudal gradient with its high end in the apical region (Bellamy, '19; Hyman, '21), and later a second active region arises on the dorsal border of the blastopore. This second region becomes the high end of a second gradient, caudocephalic in direction. The evidence from susceptibility and the comparative evidence do not favor the view that these two active regions which constitute the high ends of the two gradients are primarily one periblastoporal region (compare Kingsbury, '24, p. 318). The apical region is present at the beginning of development as a region of high susceptibility and corresponds in position to the apical active region in invertebrates, which is commonly at the opposite end of the polar axis from the blastopore, and in many invertebrates no second active region appears in connection with the blastopore. Second, the observations on susceptibility show the blastoporal active region arising separately and at some distance from the apical region, not as a part of it which separates later. Third, the apical active region is present long before proliferation of mesenchyme occurs (Adelmann, '22). If we consider the direct evidence from susceptibility, from cleavage, and from the early stages of morphogenesis, the only logical conclusion seems to be that the apical region of high susceptibility, rapid division and development is primary and the region which appears later dorsal to the blastopore is secondary and separate from the first, as it is in annelids and arthropods. Fourth, the presence and direction of the secondary, caudocephalic gradient are not simply postulated (Kingsbury, '24, p. 318), but are facts of observation.

For the assumption of dominance of the high region of a gradient over other levels in the vertebrate embryo there was no direct evidence until Spemann's work appeared (Spemann, '18, '23; Spemann and Mangold, '24). In the light of Spemann's experiments, and particularly of the recent work by

Spemann and Mangold, it appears to be demonstrated beyond a question that the 'organisator' dominates other regions in some way. But even in the absence of direct evidence various facts make it highly probable that an active region in an animal embryo must dominate less active regions in its vicinity to a greater or less extent. For example, the experimental evidence for such dominance in plants is abundant and conclusive, not merely as regards the growing tips of stems, but as regards active regions in general. There are various lines of evidence which indicate that a similar dominance exists in the simpler animals, and in general a region which is made more active by stimulation dominates adjoining regions within a certain distance because transmission of the excitation occurs to some extent (Child, '24, chaps. 10, 11). It is logical to conclude that the vertebrate does not differ fundamentally from other forms in this respect. The evidence at hand indicates that where a local active region is present in protoplasm a gradient must arise, at least for a time, and some degree of dominance and subordination must exist. Such a gradient may represent "a time or age difference due to the mode of differential growth" (Kingsbury, '24, p. 318), or it may originate as a direct response to an external differential. To say that the course of vertebrate development is due to the mode of differential growth or that it is "an expression of the growth pattern" (Adelmann, '22, p. 88) is merely to state a fact. We have to account for the mode of differential growth and the growth pattern, since they must have a physiological basis of some sort. The gradient, with its relation of dominance and subordination and the possibility of physiological isolation, provides a basis for the interpretation of the most various modes of differential growth and growth patterns in both plants and animals.

As regards the general gradient relations, vertebrate development does not differ widely from annelid and arthropod development, and there can be no doubt concerning the presence of the gradients and the relation of dominance and subordination, at least in the annelids (see above). In the

absence of any other physiological interpretation and in the light of Spemann and Mangold's experiments, it appears that we are fully justified in interpreting vertebrate development in terms of gradients, dominance and physiological isolation.

The chief objections to such interpretation are best stated in Doctor Kingsbury's own words:

When the whole complex of developmental transformation is considered, the difficulties for any interpretation of the 'law,' other than that here proposed, as representing simply a time difference in growth and differentiation, become very great. If the 'law' is conceived as representing a metabolic gradient, the degree or tendency toward differentiation depending on the remoteness from the blastoporic lip (tail bud), it must be recognized that nearly the entire body wall including parts belonging to the future head would be under its sway, while the apical or cephalic region of differential growth with high metabolic rate, extensive as it undoubtedly is, would have a correspondingly limited field of dominance. Also, it must be recognized that with the completion of differential growth in the long axis, the mass of undifferentiated material constituting the tail bud disappears; the region of high metabolic rate ceases to exist, but the cephalocaudal sequence of differential change continues without a 'pace setter.' If, on the other hand, it is assumed that the regions of high metabolic rate promote differentiation so that the degree of differentiation progressively decreases with increasing distance from such centers, the apical region would possess an extensive field of dominance and a cephalocaudal gradient in differentiation would be an expression of such diminishing influence; but the caudal region of high metabolism, that of the primitive streak and tail bud, would lack the expected field of influence. The dilemma here is obvious.

Considering briefly the more important points concerned, it should be evident and has been repeatedly stated that the interpretation in terms of gradients does not apply to "the whole complex of developmental transformation," but only to the earlier stages. The gradients and the physiological relations involved are an attempt at interpretation of the way in which development gets started in an orderly manner. In previous publications the writer has often pointed out that complications may appear very early, e.g., new tissue and organ gradients, and that as differentiation of parts

progresses chemical correlation may play an increasingly important part.

Second, the evidence from susceptibility and electric potential, as well as the observed facts of development and Spemann's experiments, indicate that the secondary gradient with its high end at the blastopore lip does extend well up to the head at certain stages of development, at least in some of the vertebrates (Bellamy, '19; Hyman, '21; Hyman and Bellamy, '22). According to the susceptibility data, the posterior growing region is the most active region in the embryo at these stages and in the amphibia it remains the most active region during tail development. In still later stages the secondary gradient disappears completely, according to the data obtained thus far, and the head region again becomes dominant. Attention was called to these facts several years ago (Child, '21, pp. 250-261), and it was pointed out that this temporary inclusion of almost the whole body length in the secondary gradient provided a very satisfactory basis for interpretation of the remarkable changes in the reflex mechanisms in the amphibian cord during development. In the course of his studies on development of the nervous system in Amphibia, Coghill found that the primary reflex apparatus of *Amblystoma* is temporary and disappears completely in later stages, giving place to another of different character (Coghill, '09, '13, '14; Herrick and Coghill, '15). In the primary apparatus the afferent paths along the cord are uninterrupted by synapses up to the medulla and later still farther anteriorly. The axons from the posterior levels run practically the whole length of the cord without synapses. The efferent paths, on the other hand, show frequent synaptic interruptions. Later this whole apparatus disappears and is replaced by another in which the afferent paths are frequently interrupted by synapses and the efferent paths are uninterrupted. This is the definitive apparatus.

When we examine neuron development in relation to the gradients, we find that axons apparently tend to grow down the gradients which affect them at the time of their develop-

ment (Child, '21, pp. 185-193 and chap. 13). Such gradients may be either the general body gradients or local gradients of parts, e.g., segments, organs, or other axons or axon groups (neurobiotaxis). In general, those axons which grow down the general body gradients are long, while those which grow in the opposite direction are short. Probably they are able to grow against the general gradient only because of short local gradients, e.g., segmental gradients in the case above described. If these inferences from the data of neuron development are correct, the character of the temporary reflex mechanism in *Amblystoma*, with its long afferent and short efferent neurons, is exactly what we should expect from what we know of the gradients at that stage of development. Similarly, its disappearance and replacement by the definitive apparatus with long efferent and short afferent neurons are to be expected from the changes which occur in the gradient situation as the posterior growing region disappears. The close parallelism between this remarkable development of a temporary reflex apparatus and its replacement by another of different character and the observed sequence of events as regards the longitudinal gradients constitute ample justification for the suggestion that the gradient changes determine these changes in the nervous system. No other interpretation has been offered, and it seems difficult to find one which is so completely in accord with the facts. Finally, if these two reflex mechanisms are expressions of the gradients at different stages, there can be no doubt of the existence of physiological dominance and of its significance in vertebrate development.

As Kingsbury points out, the disappearance of the posterior growing region is the disappearance of a pacemaker, a dominant region, but development proceeds. The difficulties involved in this situation are, however, only apparent. In the first place, it has been repeatedly pointed out that the gradients are primarily the initiators of an orderly series of events in certain directions and that, after the different regions concerned are definitely determined, it makes little

difference as regards further development whether the gradient persists or not.² As regards their more general characteristics, the various body levels are certainly determined by the time the secondary gradient disappears. So far as these characteristics are concerned, therefore, the absence of this gradient and of the pacemaker does not prevent orderly progress along the lines already determined. As a matter of fact, however, the body is not left without a pacemaker when the secondary gradient disappears, for the anterior region resumes its dominance segment by segment in the posterior direction. This integration and subordination of the segments to the head region are associated with development of the nervous system, and it is suggested that the replacement of the temporary by the definitive reflex apparatus along the cord of *Amblystoma* is an expression of the change in dominance and the new integration. So far as specialization and relation of parts are not already fixedly determined, this definitive dominance of anterior over posterior levels with the head region as pacemaker determines them. This definitive dominance is undoubtedly largely nervous in character and integrates the segments into an orderly series subordinated as a whole to the head. Viewed in this light, this series of events does not involve us in any dilemma.

As regards the dorsoventral gradient, it is evident that development progresses from the median dorsal region laterally and ventrally. This gradient unquestionably undergoes complication as localized tissues and organs arise, and to what extent the original gradient persists in later stages is a question.

Various facts indicate that, at least in certain tissues or organs of the anterior head region and at certain stages, a

²In this connection see the discussion of mosaic development by Child ('24, pp. 146-149, 244-245). The experiments on the grafting of vertebrate primordia show very clearly that a primordium, after it is once determined, may undergo further development independently of its position with respect to other parts, and may even determine developmental processes in its new environment. See, for example, Hoadley's experiments with chick primordia (Hoadley, '24) and the work of Harrison, Spemann, and many others on amphibian grafts.

gradient with its high end at the more posterior levels of the head exists, but this is apparently a secondary gradient and probably does not involve all parts. It cannot be emphasized too strongly that the interpretation of vertebrate development in terms of gradients does not demand that the gradients of early stages remain unchanged, nor does it assume that the gradients run through the body irrespective of tissues and organs. As differentiation progresses, tissue and organ gradients appear and become important and the original general axial gradients may disappear more or less completely, apparently earlier in some parts than in others.

THE TWO KINDS OF DOMINANT REGIONS

Like all other segmented animals, the vertebrates possess in development two sorts of dominant regions: the primary, differentiating early and becoming the head or part of it; the secondary, a region in which rapid cell division and growth continue to a relatively late stage. This secondary dominant region remains more or less embryonic in character as long as it persists, and in that respect resembles the growing tip of a plant axis. At present we know nothing concerning the nature of the physiological conditions which determine the character of this secondary dominant region and can only point to certain possibilities. According to the evidence at hand, it is in animals always the dominant region of the primary gradient which undergoes early differentiation and the secondary region in which cell division and growth continue for a longer or shorter time. In many of the simpler animals, as well as in the vertebrates, a secondary active region appears basally as the result of a certain degree of physiological isolation, but as long as the isolation is not complete or nearly so it remains a growing tip, and differentiates into a new apical end only when it is no longer inhibited by the primary apical region. The hydroid stolon, for example, is such an axis. It arises with a certain degree of isolation, but its tip remains a growing tip and does not differentiate until free from the inhibiting action of the primary apical region; when it does become free, it gives rise to a new hydranth.

In the light of our knowledge of axial relations in the simpler animals, for which in many cases we have experimental evidence, the logical inference is that the secondary active region originates in consequence of some degree of physiological isolation, but that it is already somewhat specialized and cannot itself give rise to a complete new individual, but only to partial individuals, i.e., segments. If this suggestion is correct, the development of new complete head regions in connection with grafts of the 'Organisator' in Spemann's experiments may perhaps be regarded as a reconstitution in the tissues of the acceptor of the graft. These suggestions, however, are at present little more than guesses and the problem of the physiological conditions determining the behavior in development of the secondary dominant region remains for the future.

In conclusion, it may be emphasized again that the gradient interpretation of vertebrate development is not in any way in conflict with the view that vertebrate development is an expression of a 'mode of differential growth' or of a certain 'growth pattern.' It is merely an attempt, based on various lines of evidence, to account for the observed mode of differential growth or growth pattern. This mode or pattern must have a physiological foundation, and the facts at hand indicate that the gradients and the relations of dominance and subordination associated with them are essential factors in that foundation.

SUMMARY

1. The significance of the gradients in the development and reconstitution of the simpler animals is experimentally demonstrated, and the evidence at hand indicates that they are not merely expressions of some more fundamental axiate pattern of unknown nature, but the physiological basis of polarity and symmetry.

2. As regards the gradients, the development of vertebrates is much like that of annelids and apparently of arthropods. In annelids the secondary active region apparently arises in

consequence of a certain degree of physiological isolation and may temporarily dominate most of the body length. Later, the dominance of the anterior end extends posteriorly, but in many annelids the posterior region is never completely subordinated to the head.

3. The data of vertebrate development show a primary cephalocaudal gradient: the origin of a secondary active region, apparently through a certain degree of physiological isolation, the development of a secondary caudocephalic gradient, the temporary inclusion of most of the body length in this gradient, and, finally, the disappearance of the posterior active region and the integration of the segments by extension posteriorly of the dominance of the head region.

4. Physiological gradients appear to be chiefly significant in initiating orderly series of developmental events in definite directions. After definite determination of parts has occurred along an axis, it makes little difference whether the gradient concerned persists or not. The gradients of early developmental stages may undergo complication, alteration, or even complete obliteration in later stages.

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NOTES ON THE APPLICATION OF EXPERIMENTAL METHODS UPON MAMMALIAN EMBRYOS

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While the experimental method has been applied to many forms among the vertebrates in which the developmental mechanics of the embryo have been studied, by far the greater amount of work has been carried out upon the amphibia which lend themselves most readily to this form of experimentation. The mammalian embryo has been practically untouched because of the many natural difficulties which are present.

Recent studies upon the transplantation of eyes in adult mammals by Koppányi ('23) have rendered it imperative that more should be known about the early mechanics of development in the mammal. The possibilities of regeneration which may be present at some early stage of mammalian development must be determined. The time of permanent differentiation of parts which cannot be changed by experimental procedure should be ascertained.

It was with these factors in mind that the studies which are here reported were begun two years ago at the University of Pittsburgh School of Medicine,¹ the present report constituting only the method of approach to the problem and pointing out some of the future possibilities to which this method is capable of application.

The studies so far conducted upon the mammalian fetus are discussed in a paper by Swensen ('25). He cites Bichat,

¹ The experiments were performed in the Anatomical Laboratory, School of Medicine, University of Pittsburgh.

Preyer, and Zuntz as having made observations upon mammals at an early stage. His own contribution deals with the possibility of direct observations upon rat embryos after creating cerebral anaemia by the ligation of the carotids. He was able to stimulate the embryos both mechanically and electrically by manipulating the embryos in a water-bath. All the experiments cited by him are those in which the fetus has been removed from the uterus, the placental site being undisturbed, and placed in a fluid medium for study. Under these conditions, the time of observation is necessarily limited. The references are not at present at hand and I refer to them only as cited from Swensen's article.

My own studies are concerned with the reaction of the fetus after operation. The preliminary study involves the following questions:

1. Can a mammalian embryo be subjected to operative procedure in utero and remain viable through the completion of the gestation period?
2. What are the possibilities of wound healing: *a*) by the embryo; *b*) in the embryonic coverings; *c*) in the uterine wall?
3. What is the best method of operative approach which will give the best results with the minimum of manipulation and the greatest completeness of surgical repair?

The present paper is an answer to the first and third questions, leaving the second for a more complete discussion in another communication.

MATERIAL AND METHODS

The rat is a very suitable animal for experimentation of this kind. The animal is exceedingly resistant to ordinary infections, is capable of rather long periods of anaesthetization without bad effects, and recovers readily from the operation.

The animals are prepared for operation by preliminary anaesthesia, at which time the area of operation is prepared by shaving. The skin area is then washed and painted with iodine. An incision is made through the skin and superficial

fascia extending from just below the margin of the ribs to a point just anterior to the posterior limb. This incision is slightly lateral to the long muscles of the back. A second incision is made somewhat lateral to the first incision through the underlying muscle layer, and this layer is dissected even farther laterally before making the final incision into the abdominal cavity.²

With ordinary care there is little bleeding to occlude visibility in the field of operation. The incision exposes the lower portion of the kidney and slight retraction of the wound edges brings the horn of the uterus of the operated side into view. The ovary also is in plain sight. The uterine horn is then grasped with a pair of fine forceps and brought to the level of the incision for inspection. If embryos are found in the tube, one is chosen for the operation and is brought to the previously prepared skin surface, upon which it is laid for subsequent manipulation.

The embryo is now in plain view, is clearly visible through the uterine wall, and is in position for the operation. The placental site is carefully noted and carefully avoided during the operation. A small slit is made in the uterine wall and the amniotic sac is punctured to permit the drainage of the amniotic fluid. This relieves the tension upon the uterine wall. The incision for removing the amniotic fluid should be made as nearly as possible over the area of the embryo upon which the subsequent operation is to be made. The embryo is fairly movable inside the uterine wall after the drainage of the amniotic fluid, and it is possible to move the part to be operated to a more favorable position even if the initial uterine incision should not be in such location.

The incision in the uterine wall must be as small as possible with the smaller embryos. An incision made with a fine needle

² The posterior method of approach as used in mammalian operations first appears in the literature in Biedl's work. It has since then been quite widely applied to different types of procedure. The recent publications using this method are those of MacDowell, *Anat. Rec.*, vol. 27, and Davenport, *Jour. Exp. Zool.*, vol. 42.

is sufficient to drain the amniotic fluid from embryos of twelve to fourteen days and also to permit the operation upon the embryo. If the incision is too large, there is a great possibility that the embryo may be extruded through the opening by contraction of the uterine musculature. Once extruded, it is practically impossible to replace the embryo within the uterus and also to repair the tear in the wall. Extrusion of the embryo generally dislodges the placental site, and the animal is lost.

Individuals which have been extruded from the uterus have remained viable for several hours, provided the placental attachment has not been disturbed. Experiments to be reported later will deal with the conditions occurring in animals which have been removed from the uterus and permitted to undergo development within the abdominal cavity.

In the experiments here reported, the operations were carried on within the uterine wall, and the organ, a limb, tail, or eye removed through the primary incision in the uterine wall.

Excision of parts was accomplished by initial ligation with a subsequent cut in the case of the limb and the tail, but cutting with a fine pair of iridectomy scissors in the case of the eye. The first two operations entail no loss of foetal blood, the second occasions a small amount of hemorrhage, which, however, is easily checked by the introduction of a small cotton sponge.

After the excision of a part, the fetus is moved about in the uterus so that the operated area is not in proximity with the opening in the uterine wall. The incision is then surgically repaired.

Steps in surgical repair are as follows: No attempt is made to repair the amniotic sac. Whether this is healed and the amniotic fluid replaced in the processes of healing cannot at present be stated. Attempted repair causes more serious damage than permitting the amnion to go unrepaired. If the embryos are in the early stages of development, it is better not to attempt repair of the uterine wall. In all animals,

however, operated after the sixteenth day of development it is necessary to suture the uterine wall due to the increase in size of the uterine incision during manipulation of the embryo. In this case the uterine wall may be closed by suture, using fine silk thread and the smallest obtainable needles; the uterine horn and its contents are then replaced within the abdominal cavity and the repair of the body wall is undertaken.

In the rat care must be taken in the repair of the body wall. The superficial stitches are often removed by the animal and, unless the underlying repair has been carefully performed, there is danger of herniation. It was for this specific reason that the initial incision was made as described above. The repair of this incision entails a double overlapping of the tissues concerned. The lower muscle layer is joined with a continuous suture, a second series of interrupted sutures joins the edges of the second muscle layer. A final series of interrupted sutures joins the edges of the skin and superficial fascia. After completing the final skin suture, the wound area is cleaned and the animal returned to its cage.

The first group of experiments was planned to show the possibilities of this type of operation and to give some indication of the future value of such procedure. The operations upon rats have formed the bulk of the preliminary work and is the group considered in this communication. Operations of a similar nature have been conducted upon cats with promising results.

Since the feasibility of the operation is the first big question, the actual operation served only to demark a certain animal from the rest of the litter. This was accomplished by the excision of a leg or of the tail. The experiments fall naturally into groups according to the age of the embryo.

The results tabulated in table 1 show that the operation is feasible and that a fair percentage of animals operated in utero may be recovered at the end of the normal gestation period. If, as has been done in subsequent experiments, it is desired to study the embryonic reactions during a short inter-

val of development after operation, the operated fetus can be recovered in every case by reoperating the mother and removing the fetus at the end of several days' development subsequent to the first operation.

The age of embryos, unfortunately, has not been accurately timed. The age given in table 1 is an approximation based on the general size and development of the embryo. This has been checked against the Wistar table for weight, which serves very well for the immediate problem. If a control animal is desired as a check on the age of the embryo at the time of operation, an embryo may be removed from the tube in which the operated animal is contained. Preferably, this is the animal attached next to the operated animal.

The advisable method of approach would seem, at first sight, to be through the anterior abdominal wall. This would give a wide field of operation and would expose both horns of the uterus with their contained embryos. All of the initial experiments were performed in this way. It was found, however, that the posterolateral approach is far better for the following reasons:

1. The amount of shock incident to handling of the viscera is avoided. Such handling of viscera is necessary in all anterior operations in order to inspect the uterine contents.

2. There is less displacement of parts and less necessary manipulation of the uterus itself, for the uterine horns are found practically in contact with the body wall.

3. Healing of the body wall and its repair is more complete. The wound can be kept cleaner and is less apt to become infected through contact with the cage flooring.

4. A better and stronger surgical repair can be secured through an overlapping of the muscular layers.

5. While the field of operation is necessarily more restricted, it is not advisable to operate too many embryos, for the increased shock is generally productive of abortion.

I have purposely omitted from table 1 the list of unsuccessful experiments performed before the development of the present technique. It is sufficient to state that a minimum

of manipulation is necessary to give positive results. Multiple operations, while they are not impossible, increase in direct ratio the chances of losing the whole experiment.

The removal of all embryos from one horn of the uterus, with the exception of the one animal operated in order to secure for the one operated greater nutritional possibilities, is not practically sound because of the increase in amount of operative shock.

TABLE 1

ANIMALS OPERATED	AGE OF EMBRYO	DAYS BEFORE BIRTH	LITTER BORN	REMARKS
	<i>Days</i>			
6	12	9	Normal term	{ 4 lost 2 recovered with litter
9	14	7	Normal term	{ 5 lost 4 recovered, all viable
11	17	4	Normal term	{ 3 born dead, 2 lost 6 recovered, all viable
27	18	3	Normal term	{ 7 born dead, 6 lost 14 recovered, all viable
29	19	2	Sometimes premature	{ 9 lost ¹ 16 recovered, all viable
22	20	1	Generally premature	{ 8 lost 14 recovered, all viable

Embryos are recorded as lost when absent from the litter upon inspection as soon as possible after birth. Since, unfortunately, it is impossible to have these animals under constant observations, many embryos were lost which either were born dead or else were so slightly viable that they failed to survive and were eaten before the next observation was made.

The first series of experiments in which the rat was used were those in which timed embryos were secured by surgical procedure. A pregnant female was operated through the anterior abdominal wall, one horn of the uterus was ligated near its junction with the body of the uterus and removed completely. Its contents were removed and preserved. The embryos in the remaining horn were permitted to continue development and be born at the close of the normal gestation period. The difference in time between the date of operation

¹ Four animals of this series were observed after birth, but were lost in an attempt to have them reared with the litter.

and the date of birth of the litter when subtracted from the total gestation period gives the actual age of the embryos removed by operation. This age value has been checked against several embryos in which the copulation time was observed and also by comparison with the Wistar series (The Rat, p. 23, also p. 65, tables 46 and 47, 1915 ed.). The differences in time between these groups fall well within the normal limits of error. This method is peculiarly applicable to securing graded series of rat embryos for class work.

Excessive manipulation of the abdominal viscera or an operation involving a number of incisions through the uterine wall can always cause abortion. Both of these conditions cause an excessive amount of shock. So long as the operative field is restricted and the placental site is undisturbed, there is little danger of abortion except in the last two days before the close of gestation. At this time an operation of any sort upon the mother is apt to bring about the premature birth of the litter. The young, while prematurely born, are generally viable and can be reared.

Death of the fetus in utero is generally the result of the dislodgment of the placenta from the uterine wall during manipulation of the uterus. Several observations have been secured in which the fetus has undergone partial resorption within the uterus. The fetus may become so adherent to the uterine wall because of healing after operation that it cannot be dislodged at the close of gestation. This condition has been found in the operations upon the earlier stages. Embryos operated later in development generally are born with the rest of the litter, even though they have not survived the conditions occurring subsequent to operation. The use of suture material in the uterine wall tends to increase the possibility of adhesion due to decreased distensibility of the uterine wall.

Because of the resistance which the rat seems to have to ordinary pyogenic infection, it has been found that strict aseptic precautions are not necessary. Experiments in which simply ordinary cleanliness of materials has been practiced

produce as great a percentage of positive results as those in which strict asepsis has been attempted. From this standpoint, the rat is an ideal animal for this type of experimentation.

The operation upon the embryo and the cutting of the uterine wall have no apparent effect upon the future litter-bearing possibilities of the mother. Several of my animals which have been under observation in regard to this point have given birth to normal-sized litters since the time of operation. Three of these have been reoperated and have given birth to the operated litter and also to subsequent normal litters.

The conditions tending to reduce the number of operated young which can be recovered at birth are due to several factors. The young which have been operated in utero are perceptibly weaker than their unoperated litter mates. They are, therefore, less capable of being carried over the early critical period. There is more neglect of the litter than is usual, due to the normal sequelae of operation. Frequently function of the mammary gland is retarded and nutrition is not available during the first days after birth. This is probably the main reason for the lack of maternal interest in the litter. Cannibalism on the part of the mother is not infrequent. Many animals which probably were viable at birth succumbed shortly after and were disposed of by the mother before observations could be made. The absence of a limb further lessens the chances of existence of the operated animal.

Since the experiments here reported deal only with the possibilities of completing the normal gestation period with viability at birth after an intrauterine operation, it is not necessary to detail other experiments now under way which deal with the results of extirpation and the possibilities of transplantation in this form. Experiments upon the limb and upon the nervous system have been performed and the preliminary results indicate that there is a large field in this form for the study of the reactions occurring during mammalian development.

SUMMARY

1. It is possible to operate upon the fetus of the rat and to secure these animals, operated in utero, alive at the end of the normal gestation period.

2. The rat is exceedingly applicable to this type of experimentation for the following reasons:

a. Extraordinary resistance to ordinary infections occurring after operation.

b. The size of the embryo is such that it can readily be handled.

c. The period of gestation is short and results are fairly quickly obtained.

d. The pregnant animal possesses considerable ability to withstand the operative shock without aborting.

3. The experiments so far conducted show that a limb may be extirpated, the tail may be excised, and the eye may be extirpated and that the reactions of the embryo to these types of operation may be studied throughout subsequent development.

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